Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

FIVE DOLLARS A YEAR

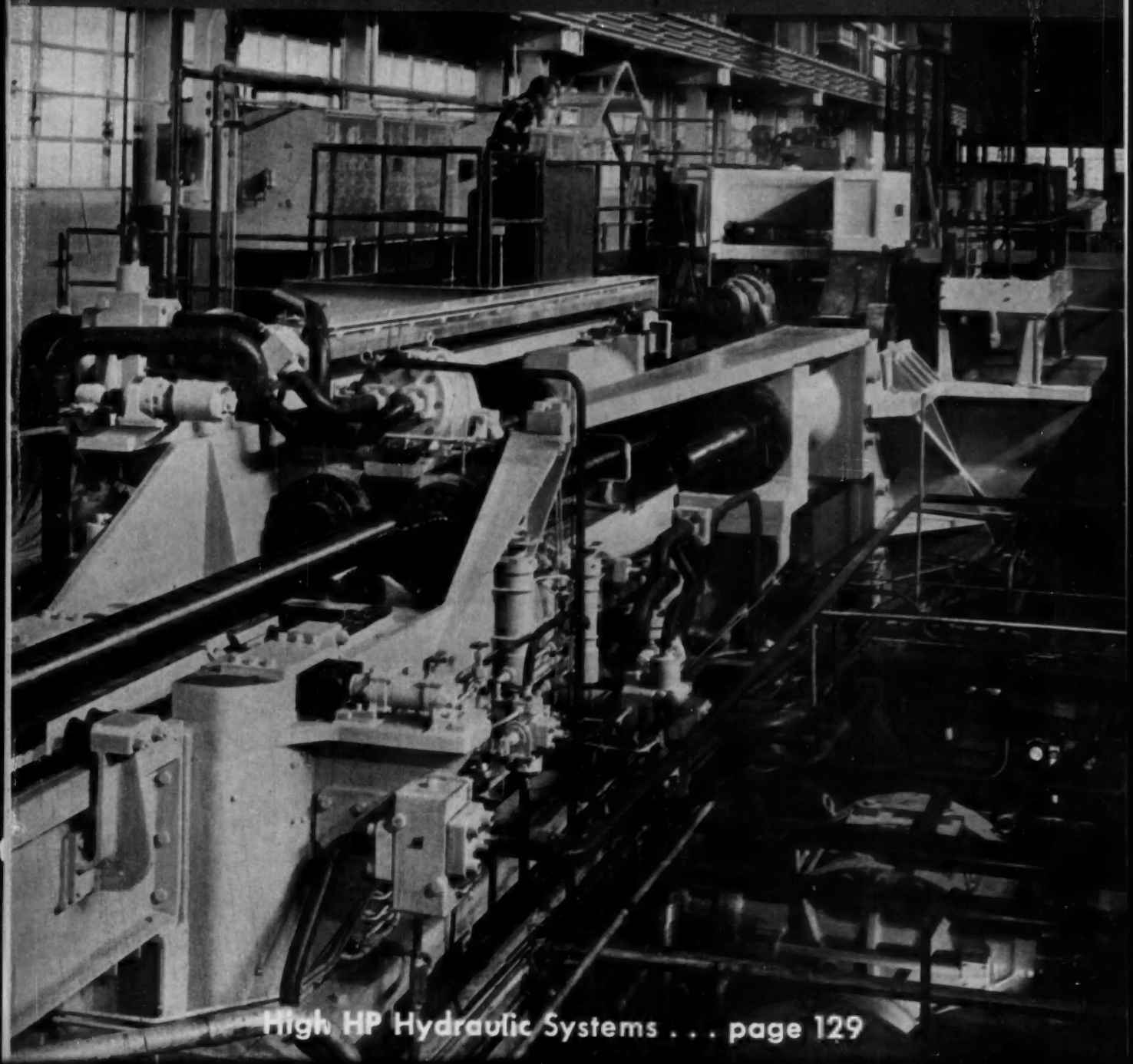
FEBRUARY 1955

Flexible Shafts
for power and control

Foamed Isocyanates

Voltage Regulators

Plaster Molding



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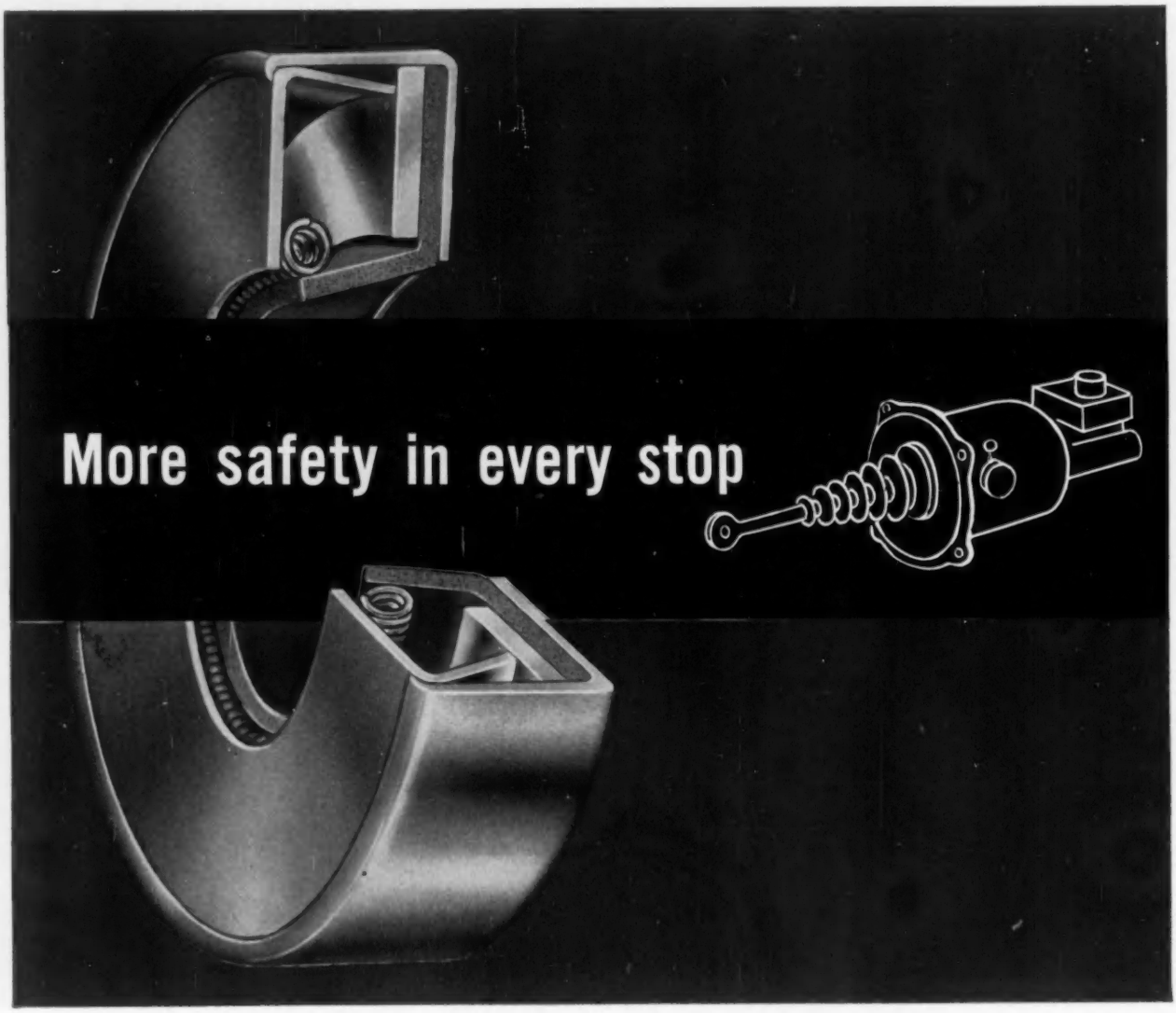

C/R SEAL BACKS UP EXTRA BRAKING POWER

Every time you touch your brake pedal it must function dependably. In a well-known power brake unit a small back-up seal is doing a big job—providing an extra margin of safety. It's a C/R Oil Seal used between the vacuum and hydraulic cylinders. The sealing element had to be designed to exacting requirements. It seals effectively on both sides, withstands pressures to 10 psi, and provides maximum flexibility to follow possible eccentricity up to .025". In thousands of applications there has never been a failure.

If your product must conform to equally high standards of performance, consider C/R Oil Seals. You may choose from 17 stock types in over 1800 sizes, or work with C/R engineers on special designs. For basic information let us send you a copy of "C/R Perfect Oil Seals."

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Oil Seals

More automobiles, farm equipment and industrial machines rely on C/R Oil Seals than on any similar sealing device.

CHICAGO RAWHIDE MANUFACTURING COMPANY

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IN CANADA: SUPER OIL SEAL MFG. CO., LTD., HAMILTON, ONTARIO

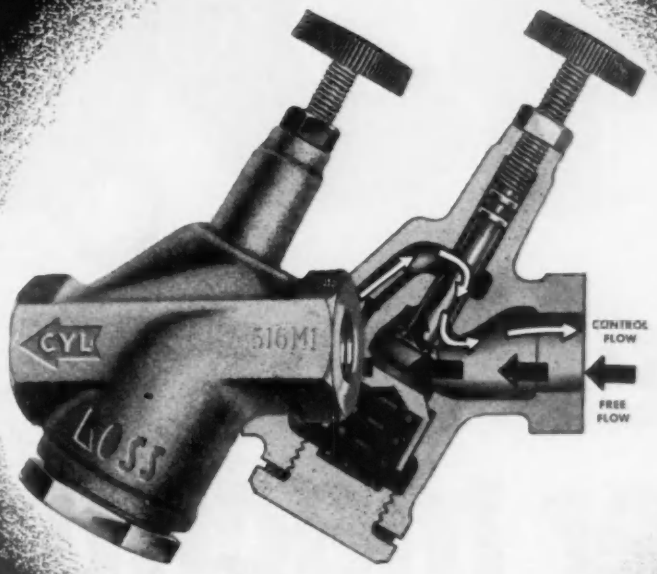
Other **C/R** *products*

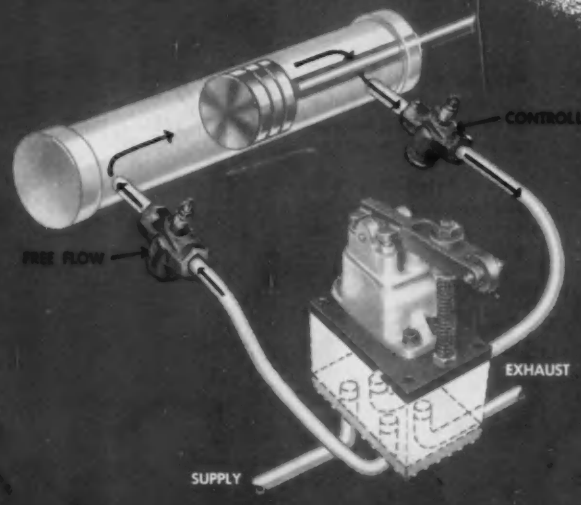
SIRVENE: (Synthetic rubber) diaphragms, boots, gaskets and similar parts for critical operating conditions • CONPOR: Controlled porosity mechanical leather packings and other sealing products • SIRVIS: Mechanical leather boots, gaskets, packings and related products.

For Precision Control . . . use

Ross

SPEED CONTROL VALVES





- Precise, simple adjustment
- Compact
- Low maintenance
- Write for Bulletin 305A

Ross OPERATING VALVE COMPANY

114 EAST GOLDEN GATE, DETROIT 3, MICHIGAN

4500 per hour per machine!

You can't beat Revere Free-Cutting Brass for speed

The mounting nuts shown here are made by the Fischer Special Mfg. Co., Cincinnati 6, Ohio, out of Revere 9/16" hexagon Free-Cutting Brass Rod. Output is 4500 per hour per machine. This phenomenal rate of production is due to special adaptations of standard machines according to Fischer designs and the high quality of Revere Rod. These two important factors enable Fischer to compete price-wise with nuts produced by other methods.

Fischer nuts are chamfered and countersunk on both sides, have no burrs, and are made in sizes from 1/8" to 1-1/16", in various designs, such as hexagon, cap, thumb, spark plug terminal, lighting fixture. As a further indication of the efficiency of the Fischer operation it can be reported that during 1953 the company averaged 244,897 pieces per running hour.

If you machine brass, look into the virtues of Revere Free-Cutting Brass. See the nearest Revere Sales Office.

FISCHER WAFER or mounting nuts, made from Revere 9/16" Free-Cutting Brass Rod at a rate of 4500 per hour.

Revere Free-Cutting Brass Rod has speeded production for many firms, and saved them money.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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Product Engineering

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Factors influencing the design of hydraulic circuits and sample calculations for determining pump and motor sizes.

A-C Voltage Regulators ..... William P. Carpenter 135
Provide stable power sources for product testing; can be used to improve performance, reliability, and life of voltage-sensitive equipment.

Foamed Isocyanates ..... Kenneth P. Satterly 140
For thermal insulation and applications requiring high strength with low density and resistance to moisture; physical properties and range of densities available.

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Emphasizing dynamic effects, complete design data are presented—including tables, charts and graphs—for profile synthesis to minimize inertia forces.

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How plaster molding is carried out in a typical foundry; applications, advantages and limitations as compared with other processes.

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Versatile MALLORY TIMER SWITCH

Gives Dependable Control for Dozens of Products

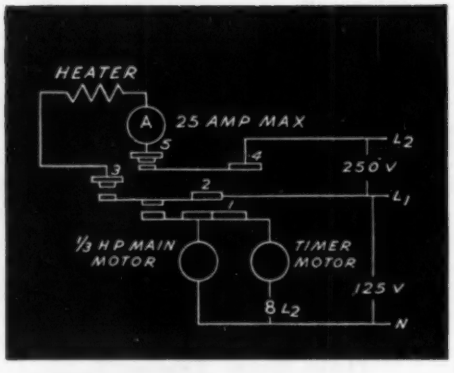
If your product needs time-cycle control, the Mallory Model W Timer Switch may be exactly what you have been looking for. Capable of switching approximately ¾ horsepower or 6000 watts resistive load, 250 volts, it is applicable to air conditioners, semi-automatic washers, automatic dryers, food dispensers and a host of similar appliances.

VERSATILE SWITCHING. One, two or three circuits can be controlled. Standard cam shaft speeds of 32, 64, 96 and 192 minutes per revolution are available . . . plus special speeds of up to 24 hours per cam revolution when desired. Cams are cut to the exact cycle required for your specific application.

FITS ANYWHERE. The compactly designed unit requires only 1¾ inches of back-of-panel space.

ECONOMICAL ASSEMBLY. Space-saving spade terminals cut time for connections. Mounting is simple . . . requires no bulky, expensive hardware.

The Model W Timer Switch is one of a wide line of standard designs developed by Mallory during many years of experience in producing switches and timers for leading manufacturers. A standard Mallory model will probably fit your own product's requirements . . . and will give you top performance at economical cost. For special requirements, our engineers are well qualified to develop custom-made designs. For technical data, write or call Mallory today.



On an automatic dryer, for example, the Model W Timer Switch controls three circuits . . . main motor and timer motor, heater, and auxiliaries.

***Expect more . . . Get more from* MALLORY**

Serving Industry with These Products:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
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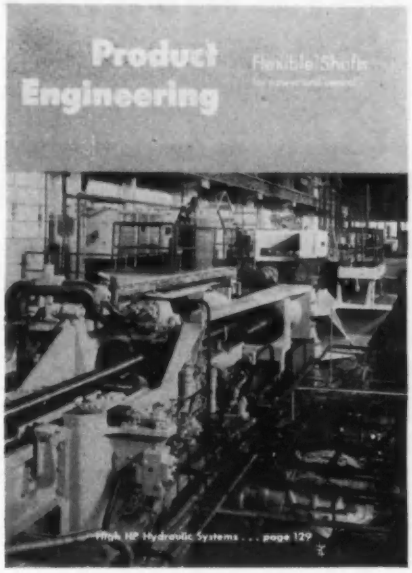

THIS MONTH'S COVER

Waterbury gear pump that delivers 2300 gpm at 3,000 psi actuates the 150 ton saddle assembly of giant tube reducing machine recently installed at Tube Reducing Corporation's new plant in Wallington, N. J. Pumps move this weight through a six foot stroke at 600 fpm starting from dead stop positions.

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Highlights

Current research and developments soon to influence product designs.

AN ULTRASONIC INSTRUMENT . . . .

. . . . makes possible—for the first time—the measurement of both the velocity and attenuation of sounds in liquids over wide ranges of temperature, pressure and frequency. According to The Naval Ordnance Laboratory, Silver Spring, Md., it will handle pressure ranges from 1 to 6,000 atmospheres and frequency ranges from 1 to 75 megacycles. In operation: a radio frequency electric field is applied to a quartz crystal transducer. This produces a sound wave which travels through the liquid to a movable reflector and is reflected back to the crystal. The echo, in turn, is shown on an oscilloscope screen. A reflector position change, varies the time of travel of the echo. The distance and time furnish a measure of the velocity of sound. The distance and change in amplitude of the echo give a measure of the attenuation. Ultrasonics, as a research tool, can be used to study all three states of matter—gases, liquids and solids. NOL will shortly begin work in solids by investigation of the magnetostrictive effects in ferro—and ferrimagnetic materials.

WATER . . . .

. . . . according to studies, may be the means used for aircraft and rockets to crash through the thermal barrier. According to scientists at the Polytechnic Institute of Brooklyn, 99 Livingston Street, Brooklyn 2, N. Y., a suggested method is to make the wings of a porous material through which water could be pumped to carry away the craft's heat as steam. Another method suggested by scientists: protect some components by ceramic coatings that could withstand temperature up to 5,000 F. And also, to make some parts from ceramic materials that might be allowed to melt. In melting these parts would carry off the heat and would probably be lighter than carrying water and pumping equipment.

A RESINOUS TYPE . . . .

. . . . of plastic adhesive than can substitute for the more expensive soft solder is in certain metal-to-metal bonds is reported by the U. S. Army in a report available from the Department of Commerce, Washington 25, D. C. The adhesive, named Araldite 115, is used in place of soft solder. In one instance, for bonding galvanized steel screens to cold-rolled steel shrouds. Adhesive may reduce cost of bonding by 50 per cent or more. Tensile strength, after all types of storage conditions, is reported to be equal in strength to soft solder.

PROOF . . . .

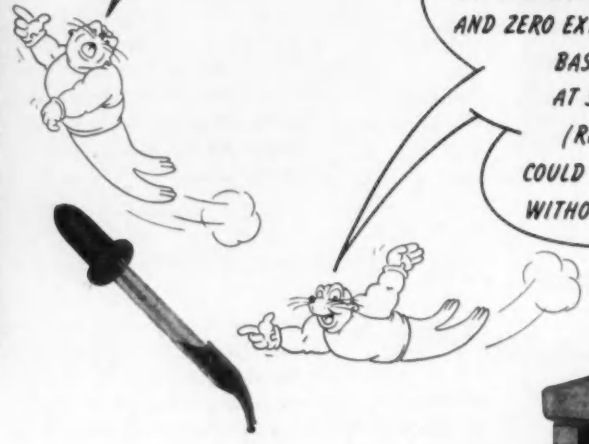
. . . . that short time laboratory creep tests do simulate service conditions is indicated by ending of tests on carbon molybdenum steel pipes. According to researchers at the University of Michigan's Engineering Research Institute, Detroit, Michigan and The Detroit Edison Co., the rate of creep of the steel pipes, after 100,000 hr at 900 F, is 0.002 per cent per 1,000 hr at 7,500 psi. This, it is claimed, is in agreement with predictions of laboratory creep data. Deterioration of creep strength from structural changes, such as spheroidization, was also in agreement with laboratory data.

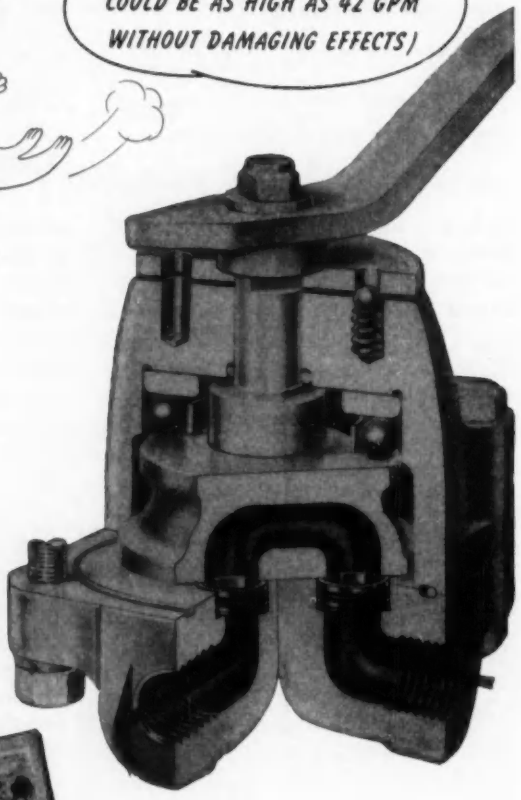
(continued on page 7)

INTERNAL VALVE LEAKAGE COSTS MONEY!

AVERAGE INTERNAL LEAKAGE PER MINUTE 20 OZ.
IN THE MOST WIDELY USED VALVE TYPE.
BASED ON 3/4" VALVE SIZE
AT 2000 PSI OIL PRESSURE
(RATED FLOW 16 GPM)

MAXIMUM INTERNAL LEAKAGE 10 DROPS
IN A BARKSDALE SHEAR-SEAL VALVE
AND ZERO EXTERNAL LEAKAGE.
BASED ON 3/4" VALVE SIZE
AT 3000 PSI OIL PRESSURE
(RATED FLOW 20.5 GPM-
COULD BE AS HIGH AS 42 GPM
WITHOUT DAMAGING EFFECTS)





There is a direct ratio between the amount of leakage in a valve and the expense from it.

Both, the leakage and the expense, are insidiously hidden. But, let's bring them out in the open (see the two measures above). Primary damage through leakage shows up as erosion, wear and high maintenance cost of the valve itself. In contrast, Shear-Seal valves actually improve their sealing qualities with each operation. (Write for "Super Seal explains the Shear-Seal Principle.")

Higher, yet hidden damage results when leaky valves constantly exhaust accumulators, overwork pumps and compressors, or increase the scrap rate through loss of working pressure.

Furthermore, leakage creates heat in your hydraulic system accelerating wear and deterioration in costly machinery and components. Ironically, the valves are often overlooked as the real culprit in such failures.

For greater operating economy and lower overall maintenance install leakproof Shear Seal valves.

Send FREE bulletin "Super Seal Explains the 'Shear-Seal' Principle."

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COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

BARKSDALE VALVES

5125 ALCOA AVENUE, LOS ANGELES 58, CALIFORNIA

Highlights

FABRICATION OF TITANIUM ALLOY . . . .

RC-70 titanium alloy is being successfully fabricated to form after-burner shrouds for jet engines. According to Chance Vought Aircraft, 9314 W. Jefferson, Dallas, Texas, the alloy is similar to half-hard stainless steel. Its springback characteristic, however, is more nearly comparable to that of ¾-hard stainless. Satisfactory fabrication results are obtained, it is reported, only with tools designed for use with titanium.

INCREASED HEATING EFFICIENCY . . . .

A brazing method that permits the brazing of aluminum sheathed Nichrome coil heating elements directly to aluminum parts has been developed. Selas Corporation of America, 548 East Erie Ave., Philadelphia 34, Pa., claims the method increases the heating efficiency by as much as 400 per cent with consequent savings in power and operating costs. Method allows the heater coil to be centered on the aluminum part and to be protected from short circuiting by ceramic insulators.

50 LB TITANIUM CASTINGS . . . .

Titanium melting and casting by a new investment casting technique is a development of the National Research Corporation, 70 Memorial Drive, Cambridge, Mass. 50 lb castings, it is reported, can be cast under vacuum or inert gases from titanium and its alloys. Melting is carried out in a furnace having a shell of titanium so that the melt will not be contaminated. Titanium sponge is used and melted in an electric arc. Recent castings have contained less than 0.06 per cent carbon.

WIDE USE SILICONE LUBRICANT . . . .

Silicone oil and grease of value to such industries as glass, steel, ceramics, petroleum and aircraft, have a thermal operating range of minus 100 to plus 400 F. According to the General Electric Company, Waterford, New York, the new oil and grease lubricate about as effectively as both lubricating and hydraulic types of hydrocarbons. Materials are reported as showing little change in viscosity or consistency at high temperatures and also, to resist shear breakdown.

SYNTHETIC PRODUCTION OF NATURAL RUBBER . . . .

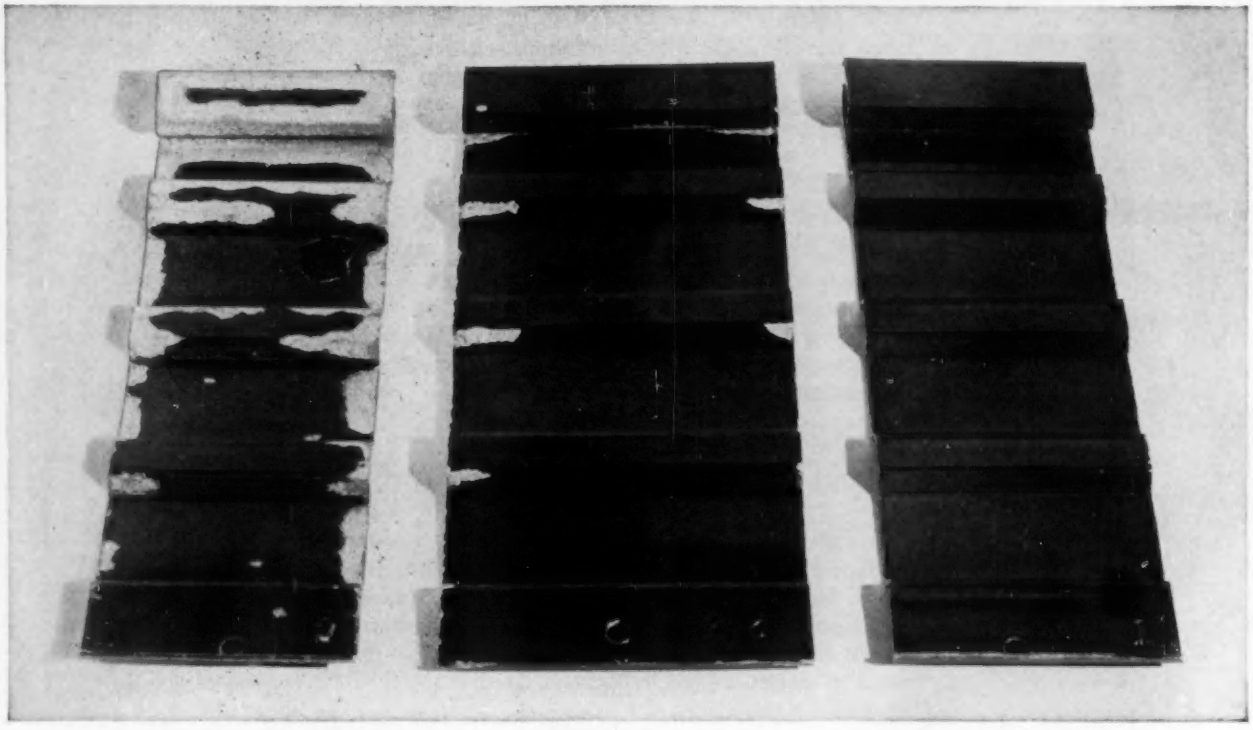
The true molecule of natural rubber by synthetic production, has been accomplished in the laboratory at Goodrich-Gulf Chemicals, Inc., 944 Oliver Bldg., Pittsburgh, Pa. It is reported that the new rubber is made of different materials than those used in making GR-S types and that it could not be produced in existing rubber facilities. Natural rubber, in some instances, is considered better than the synthetics, especially for heavy loads. Natural rubber generates less heat under load and has a lower freezing point.

PUMP FOR LIQUID METALS . . . .

A new pump operating on an electromagnetic principle may be a means of moving liquid metals within cooling or heating systems. According to Callery Chemical Co., Callery, Pa., an electric current is passed through the metal in a direction perpendicular to a magnetic field which surrounds the metal. This produces a force that sets the metal in motion within the pumping section. Pump may also be used to force liquid into forms in die casting operations.

(continued on page 9)

Better adhesion for porcelain enameled aluminum with PARKER PRE-NAMEL 420



Results of accelerated spalling test. These sections of porcelain enameled structural aluminum were immersed in 5% solution of NH_4Cl for 96 hours. Left, untreated aluminum; center, conventionally pretreated aluminum; right, aluminum pretreated with Parker Pre-Namel 420

Here is a simple, money-saving pre-treatment which results in improved adhesion of porcelain enamel on aluminum and increases the durability several times.

Parker Pre-Namel 420, applied either by immersion or spray, produces a thin coating integral with the metal. This coating is an excellent base for the porcelain enamel.

Parker Pre-Namel makes the enameling of aluminum simpler, faster, and more economical:

It eliminates the need for pre-firing, thus effectively increasing existing furnace capacity 25% or more.

It operates at room temperature.

It produces good results within a time range of 30 seconds to 10 minutes.

It minimizes carry-out of processing material.

Parker Pre-Namel solution is replenished at intervals, need never be discarded.

This new pre-treatment extends the usefulness of porcelain enameled aluminum by adding durability while reducing the cost!

*Parker Pre-Namel—Reg. U.S. Pat. Off.

Send for Technical Bulletin

Illustrated bulletin "Parker Pre-Namel 420" will be sent free, on request.

Since 1915—Leader in the Field

PARKER RUST PROOF COMPANY

2179 E. Milwaukee, Detroit 11, Michigan

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

Highlights

PNEUMATIC CONTROLLER . . . .

An indicating controller for on-off or throttling action that provides control of such variables as temperature, pressure, liquid level and humidity in processing operations has been designed by The Foxboro Co., 86 Neponset Ave., Foxboro, Mass. For on-off action, the instrument snaps the control valve from fully opened to fully closed when the measurement crosses the control point. For throttling action, a proportional unit is used that is adjustable from ¼ of 1 per cent to 25 per cent of the full scale.

HIGH SPEED, LOW COST WELDING . . . .

Arc welding process for mild steel is reported to be capable of operating at greater speed and lower costs than previous systems. And, Westinghouse Electric Co., P. O. Box 868, Pittsburgh 30, Pa., says, a smooth weld which can be painted without cleaning is produced. Speeds are reported to range 15 to 20 per cent faster than manual and semi-automatic inert gas methods. Cost reduction: about 20 to 25 per cent. Key to process is a new coated wire.

HIGH TEMPERATURE SEALING . . . .

Rubber sealing compound for such high vacuum applications as electronic devices, lens coating machinery, evaporators, high vacuum distillation, electronic microscopes and special testing devices is a development of the Minnesota Rubber and Gasket Co., 3630 Wooddale Ave., Minneapolis 16, Minn. Advantages cited for the compound are its resistance to outgassing at high temperatures and long service life. Material can be injection molded into special shapes as well as standard sizes of Quad-rings and O-rings.

NYLON-TYPE PLASTIC FOR MOLDING . . . .

A plastic molding compound that is made from a nylon-type plastic is a development of the Barrett Division, Allied Chemical and Dye Corp., 42 Rector Street, New York 6, N. Y. Claimed for the compound: greater resistance to abrasion; better gloss and color quality; and less shrinkage in molds. Also, the company believes its nylon compound may find wide use in wire coating because of its high resistance to abrasion.

FOR THE ATOMIC LABORATORY . . . .

Radiation detectors which are reported to be the lightest ever designed—one weighing 2 lb; the other 1 lb 12 oz—are developments of the Curtiss-Wright Corp., Wood-Ridge, N. J. One instrument, called a Radiameter, can be equipped with a cable for connecting external counter tubes, alpha and liquid counter tubes, a radiation source for calibration and other accessories. The smaller unit, a Radiatector, is a probe type unit with a high-intensity counter tube and amplifier. Units operate on a 1.5 v flashlight battery.

PLASTIC PIPE VS STEEL PIPE . . . .

Carbon black used to strengthen rubber polymers is being investigated as a method of increasing the bursting strength of polyethylene pipe. Godfrey L. Cabot, Inc., 77 Franklin Street, Boston 10, Mass. reports the following initial result: higher loadings of carbon black can increase the burst strength of polyethylene. The project is still in work, but it is felt, that the increase in bursting strength will permit plastic pipe to be used in many additional applications where steel is now required.

NEW!

ARMCO ALUMINUM-COATED STEEL

for outdoor service

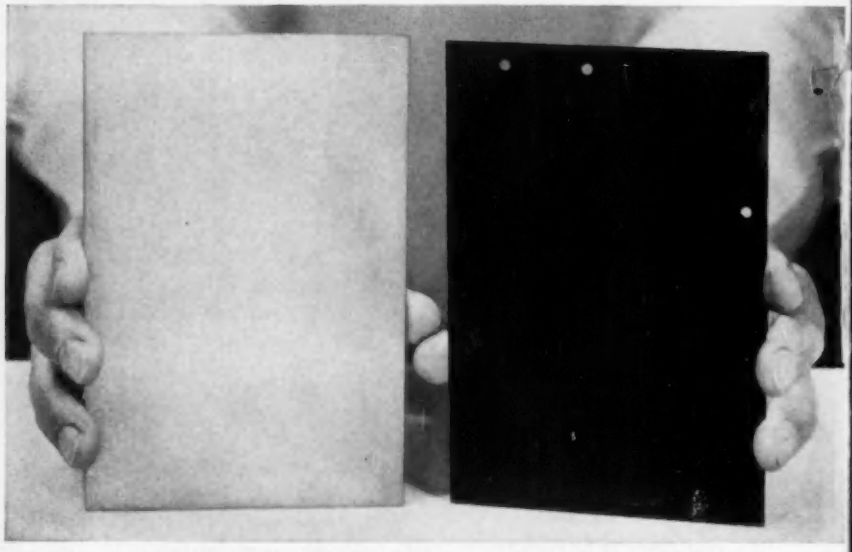
COMBINES CORROSION-RESISTING PROPERTIES OF ALUMINUM WITH STRENGTH OF STEEL

A new hot-dip aluminum-coated sheet steel—known as Armco ALUMINIZED STEEL® (Type 2)—is now in production after 15 years of corrosion testing. It combines the surface advantages of aluminum with the strength of steel.

While zinc coatings have done a good job of protecting steel against rust, tests indicate this new aluminum-coated steel is greatly superior. The 15-year tests in an industrial area show the atmospheric corrosion resistance of this aluminum coating is at least 3 times that of a standard coating on galvanized steel sheets.

During the past year and a half of field development work, ALUMINIZED STEEL (Type 2) has been used in prefabricated industrial, commercial and farm buildings, industrial rolling doors, covers for silos and water storage tanks, roof deck, and other applications under general atmospheric conditions.

The new sheet is a companion grade to Armco ALUMINIZED STEEL (Type 1) exclusively produced by Armco since 1939 for high temperature service.



In atmosphere sufficiently corrosive to cause a standard galvanized coating (right) to fail completely in 12 years, Armco ALUMINIZED STEEL (Type 2), left, looked like this *after 15 years*. Cleaned samples show the aluminum coating is still giving full protection to the base metal

QUESTIONS YOU MAY WANT ANSWERED

DOES IT "WEATHER" LIKE ALUMINUM?

Yes. The surface of samples of Armco ALUMINIZED STEEL (Type 2) and aluminum, exposed to the atmosphere for five years, cannot be told apart.

WHAT IS ITS STRENGTH?

Because it has a steel base it has the strength and rigidity of steel . . . thus avoiding problems common to weaker materials.

DOES IT REFLECT HEAT?

Yes, ALUMINIZED STEEL (Type 2) offers the same high reflectivity of radiant heat as aluminum—whether from the sun or from low temperature heat sources.

DOES IT RESIST FIRE DAMAGE?

Armco ALUMINIZED STEEL has excellent resistance to fire damage. At 800 F, for example, it has more than ten times the strength of aluminum. Steel has a melting point of 2850 F; aluminum melts at about 1200 F.

WHAT ABOUT FABRICATION?

Armco ALUMINIZED STEEL (Type 2) withstands severe forming without peeling or flaking of the coating. It also can be embossed and spun, but is not recommended for drawing operations.

HOW DOES IT COMPARE IN COST?

Even when considering equal thicknesses, ALUMINIZED STEEL (Type 2) generally costs less per square foot than aluminum. Additional cost savings are possible because the greater strength of the steel base permits use of lighter gages. For example, a fabricator using .050 aluminum could save 40 to 50 per cent of material costs by utilizing the proper gage of ALUMINIZED STEEL.

While the initial cost is somewhat higher than galvanized steel, it is less than the cost of galvanized plus one field coat of paint. Because of its superior atmospheric corrosion resistance, the new aluminum-coated steel needs no paint protection.

If you would like complete information on sizes, gages and prices of Armco ALUMINIZED STEEL (Type 2), just fill in and mail the coupon.

ARMCO STEEL CORPORATION

955 Curtis Street, Middletown, Ohio

Sheffield Steel Division • Armco Drainage & Metal Products, Inc. • The Armco International Corporation

ARMCO®

ARMCO STEEL CORPORATION

955 Curtis Street, Middletown, Ohio

What are sizes, gages and prices of Armco ALUMINIZED STEEL (Type 2)?

We manufacture _____

_____

NAME _____

TITLE _____

COMPANY _____

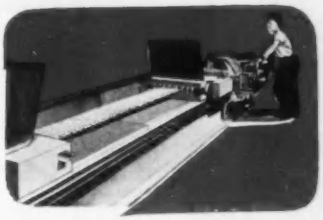
STREET _____

CITY _____ ZONE _____ STATE _____

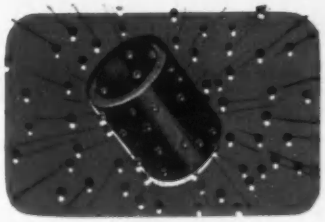
These LINK-BELT Roller Chain EXTRAS

put more life into your machines

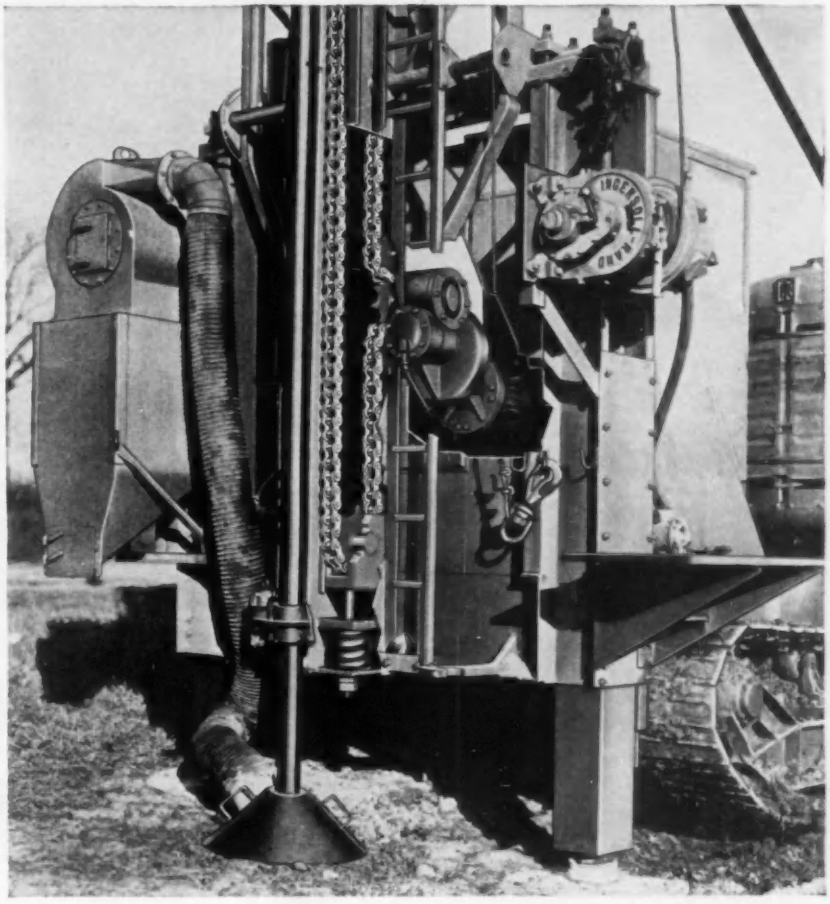
LOCK-TYPE BUSHINGS (applied on a range of sizes) end a common cause of stiff chain.



PRE-STRESSING of multiple width chain provides uniform load distribution.



SHOT-PEENED ROLLERS have greater fatigue life, added ability to withstand impact.



Ingersoll-Rand uses Link-Belt Precision Steel Roller Chain for positive drill feed on their Quarrymaster primary blast-hole drill.

THROUGHOUT every stage of manufacture, Link-Belt takes *extra* care to build *extra* life into Precision Steel Roller Chain. Shown above are three of these added refinements . . . and there are many others which contribute to better performance and longer life for your machines.

You can choose from a wide range of Link-Belt roller chains and sprockets. In addition, Link-Belt's complete line includes silent chain drives . . . and all sizes and types of cast, combination, forged and fabricated steel chain.

Data Book 2457 will aid you in selecting and ordering roller chain. Get your copy from the nearest Link-Belt office now. And remember to see Link-Belt for all your drive and conveying chain needs.

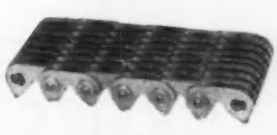
LINK-BELT

CHAINS and SPROCKETS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

13,720

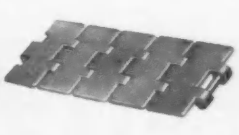
No one chain serves every purpose . . . get the RIGHT one from Link-Belt's complete line



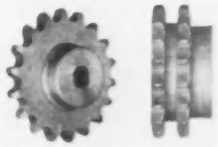
Silent Chain

LXS Steel Chain

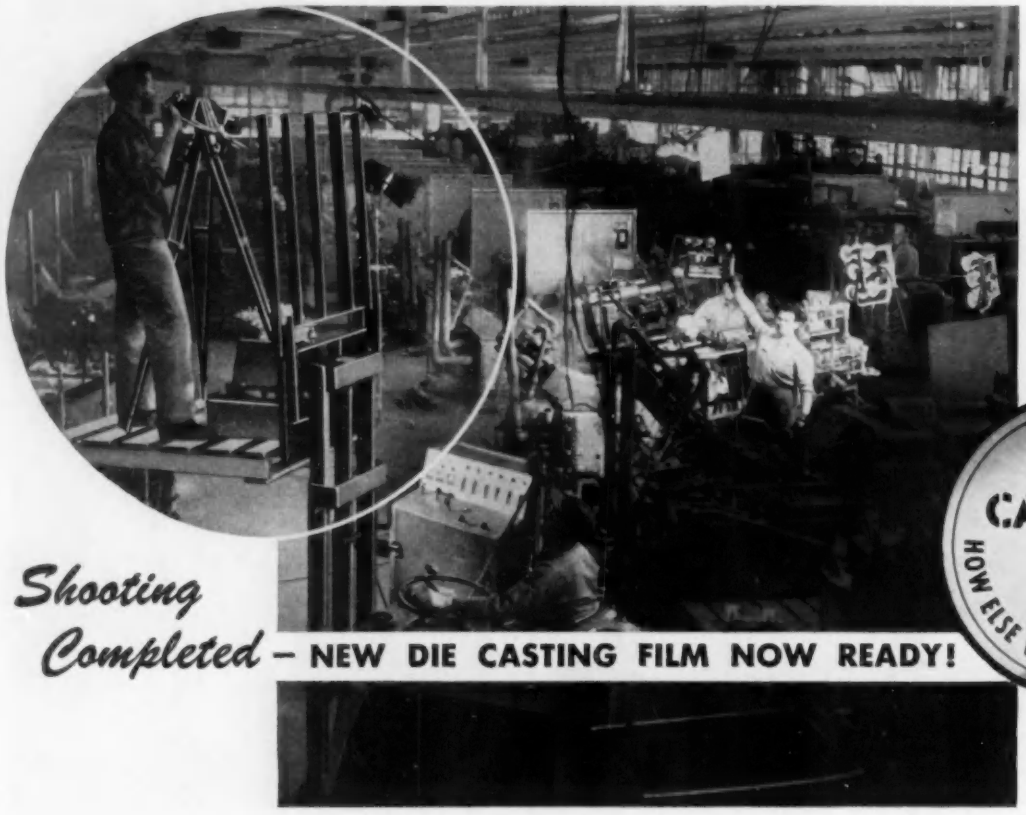
Detachable Steel Link-Belt



S-815 Flat-Top Chain



Cast and Cut-Tooth Sprockets



Shooting Completed – **NEW DIE CASTING FILM NOW READY!**

Get the Facts on ZINC Die Casting ECONOMIES

When you see the new motion picture "DIE CASTING—How Else Would You Make It?" (just released by the American Zinc Institute, Inc.) you will learn the basic reasons why ZINC Die Castings are so low in cost. You will find, for example, that their economy begins with the kind of machine on which they are produced.

The above scene from the new film shows a battery of high speed ZINC die casting machines. *Only* ZINC, among the principal die casting metals, can be cast in these machines. And this maximum production speed means minimum die casting costs to you.

But the 35-minute motion picture is not confined to the actual casting procedure. It also covers part design, die design, secondary operations, finishing and applications. It not only will help you to bring ZINC into proper focus among die casting metals but it establishes the relationship of die casting to other high speed production methods.

HOW TO SEE THE NEW FILM—

If you have access to projection equipment (the film is 16 mm. Kodachrome with sound) and can arrange to get a group together to see the picture, a print can be borrowed free-of-charge from the American Zinc Institute, Inc., 60 East 42nd Street, New York 17, New York. When writing, try to give several alternate dates for the showing and advise the size of the audience (you will also receive copies of a new 24-page booklet on die castings for those viewing the film).

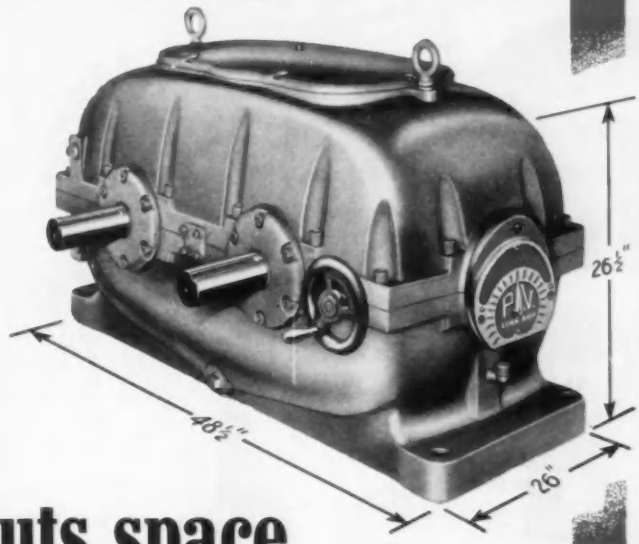
The New Jersey Zinc Company
160 Front St., New York 38, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

LINK-BELT 25-hp P.I.V. Variable Speed Drive



cuts space requirements up to 50%

LINK-BELT gives you all the advantages of positive, stepless speed changing in high horsepowers, too

ONE of the great advantages of P.I.V.'s positive, all-metal drive is dramatically illustrated by the Size 6. Compared to other speed changers in this hp range, it saves *70 cu. ft. of space!*

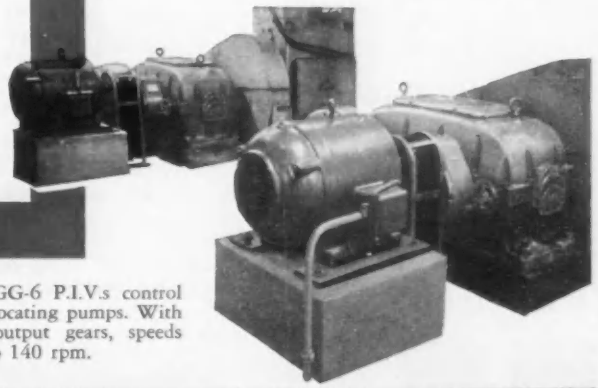
In addition, infinitely stepless regulation means you can select the exact speed you want—from maximum to minimum. Unaffected by temperature and atmospheric conditions, all moving parts are totally enclosed and splash-lubricated.

The Size 6 P.I.V. is built in three types: The basic drive . . . with input *or* output gears . . . with input *and* output gears. All are available in a wide range of ratios, 20 to 25 hp.

Get the facts on the Size 6 from your nearest Link-Belt office or distributor. You'll receive a copy of Folder 2374. And for information on the complete P.I.V. line, ask for Book 2274.

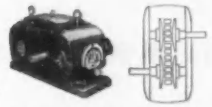
LINK-BELT P.I.V. VARIABLE SPEED DRIVE 13,594

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

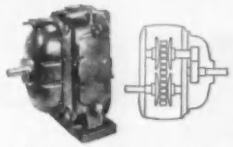


Two Link-Belt HGG-6 P.I.V.s control the speed of reciprocating pumps. With both input and output gears, speeds range from 46.5 to 140 rpm.

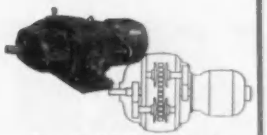
4 OF 16 P.I.V. TYPES
HORIZONTAL OR VERTICAL MOUNTINGS
½ TO 25 HP—
RATIOS TO 6:1



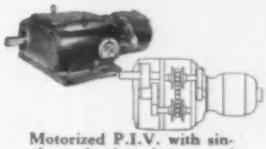
Basic, Positive, Infinitely Variable (P.I.V.) Speed Drive.



P.I.V. with single reduction input or output helical gears.

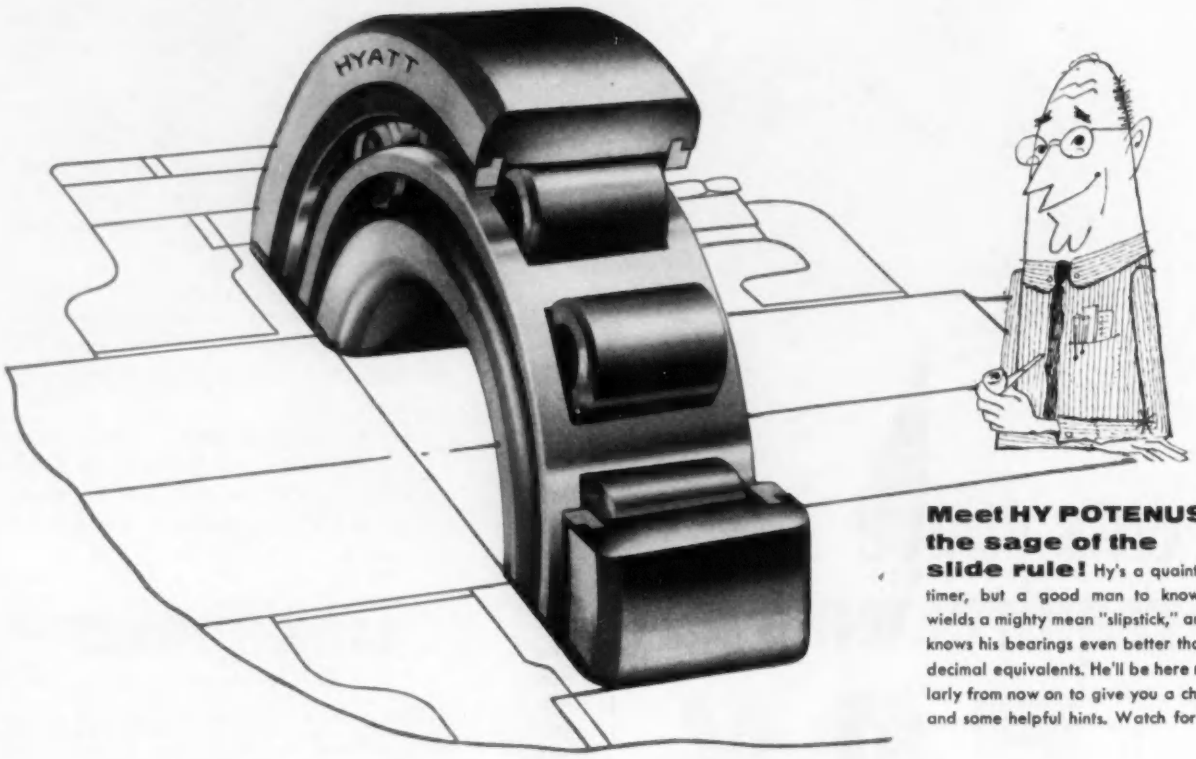


Motorized P.I.V. with single reduction input and output helical gears.



Motorized P.I.V. with single reduction input and double reduction output helical gears.

How Hy-Loads can help you LICK LATERAL SHAFT EXPANSION!



Meet HY POTENUSE, the sage of the slide rule! Hy's a quaint old-timer, but a good man to know. He wields a mighty mean "slipstick," and he knows his bearings even better than his decimal equivalents. He'll be here regularly from now on to give you a chuckle and some helpful hints. Watch for him!

YOUR COMPLETE LINE OF CYLINDRICAL ROLLER BEARINGS

HY SAYS:

Ever stumped by a spot where the shaft heats up and expands laterally—say in an electric motor? You know what happens with laterally locked bearings—you get cramping, misalignment, trouble with a capital T!

But a HYATT Cylindrical Roller Bearing solves all those problems so simply! It allows the shaft to float horizontally—"free lateral," we call it—and automatically compensates for expansion *without changing the bearing centers.* If you haven't a HYATT catalog handy, better send for yours right now. It'll show you exactly which bearing to use where, and help you find the *right* answers to a lot of pesky bearing problems. *Remember, you can't go awry when you specify—*

HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

The case of the

BEAUTIFUL FRAME

Handbag product of The Randolph-Rand Corporation, New Rochelle, New York.

A well-known handbag manufacturer who'd been having a problem getting a beautiful finish on brass frames at a low production cost called on Bridgeport's Technical Service for assistance.

Here's the case history: After careful study of his problem, a Bridgeport Fine Grain Brass — *custom made to the exact grain size best suited to the manufacturer's requirements* — was recommended. This vanity case quality metal was selected because the fine grain surface needs little finishing and the brass works well. Look at those 90° bends, for example, and notice how the brass is stiff enough to hold the cloth of the bag by itself.

By using Bridgeport Fine Grain Brass and improved techniques, a beautiful, lustrous finish was attained and *production per man in the finishing department increased five times.*

This is another case history to prove that *no single fine grain brass can do all jobs well.* A whole range of fine grain sizes is available, and since there is no one pat answer for all finishing problems, Bridgeport recommends the exact fine grain size only after consideration of all factors.

To find out how Bridgeport can help you improve your product and lower manufacturing costs with the right metal for your needs, call your nearest Bridgeport Sales Office.

Write for a free copy of Bridgeport's folder on Grain Size — "The Fourth Dimension."

BRIDGEPORT BRASS COMPANY ◆ BRIDGEPORT, CONNECTICUT

Serving Industry With a Network of Conveniently Located Sales Offices and Warehouses

Mills at Bridgeport, Conn., Indianapolis, Ind., and Adrian, Mich.

In Canada: Noranda Copper and Brass Limited, Montreal

Farval helps mill and drill a camshaft every 13 seconds

FARVAL—
Studies in Centralized Lubrication
No. 164

CENTRALIZED lubrication is a must for automatic production on machine tools like this Kearney & Trecker four-station rotary indexing machine. Protected by a Farval centralized system, this machine mills and drills 288 camshafts an hour.

There's never any time lost for oiling or greasing because *Farval lubricates while a machine is in operation.* Uncounted hundreds of hours of oiling labor are saved, too. Thus, this foolproof system of lubrication keeps machines producing parts faster and at less cost, and keeps maintenance costs at a minimum. Once Farval has been installed on a machine tool, it soon pays for itself *—often in a matter of a few months!*

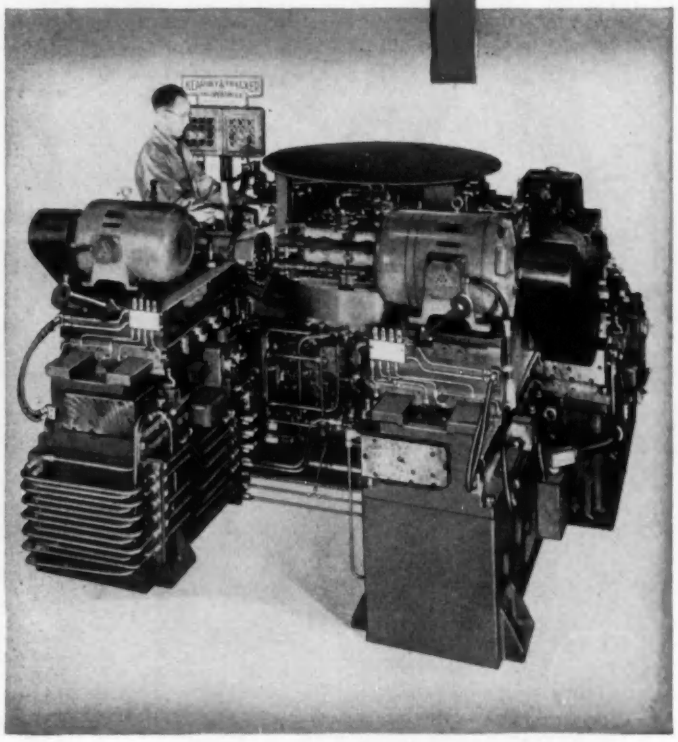
How Farval Works

FARVAL is the Dualine system of centralized lubrication that delivers a measured amount of clean lubricant at regular intervals to *every* bearing. From a central station, lubricant is pumped under pressure, by hand lever or automatically, to a measuring valve at each bearing, delivering the *exact* amount of lubricant required.

Free Lubrication Survey

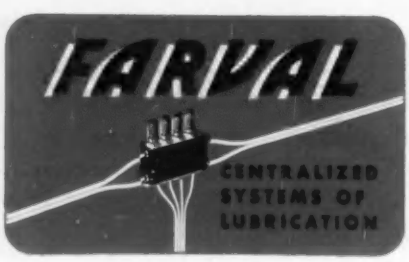
Let us send one of our lubrication engineers to inspect your plant equipment. Without obligation, he will present a written analysis of what Farval can do for you. Write for Bulletin 26 for the complete Farval story. The Farval Corporation, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



KEYS TO ADEQUATE LUBRICATION— Wherever you see these Farval valve manifolds, dual lubricant lines and central pumping station, you know a machine is being properly lubricated.

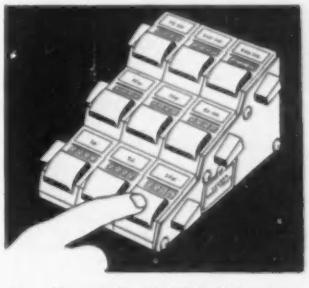
This Kearney & Trecker four-station rotary indexing machine at a famous automobile plant has 22 points of lubrication served by a Farval automatic system handling light oil.



Added Evidence that . . .

Everyone Can Count on VEEDER-ROOT

In figuring out new systems of automatic electrical control, Veeder-Root *Count*rol can supply vital connecting links. For instance, this Predetermining Counter can be hooked into such a system to light a light, ring a bell, or actuate a mechanism to stop a machine or process *at any pre-set point*. And there are many other Veeder-Root Counters that can serve as "countponents" in almost any way desired. Or special counters can be designed for specific applications. Engineers in any industry, now engaged in working out automatic control systems, can count on Veeder-Root engineers to work with them on any problem where reliable facts-in-figures are needed.

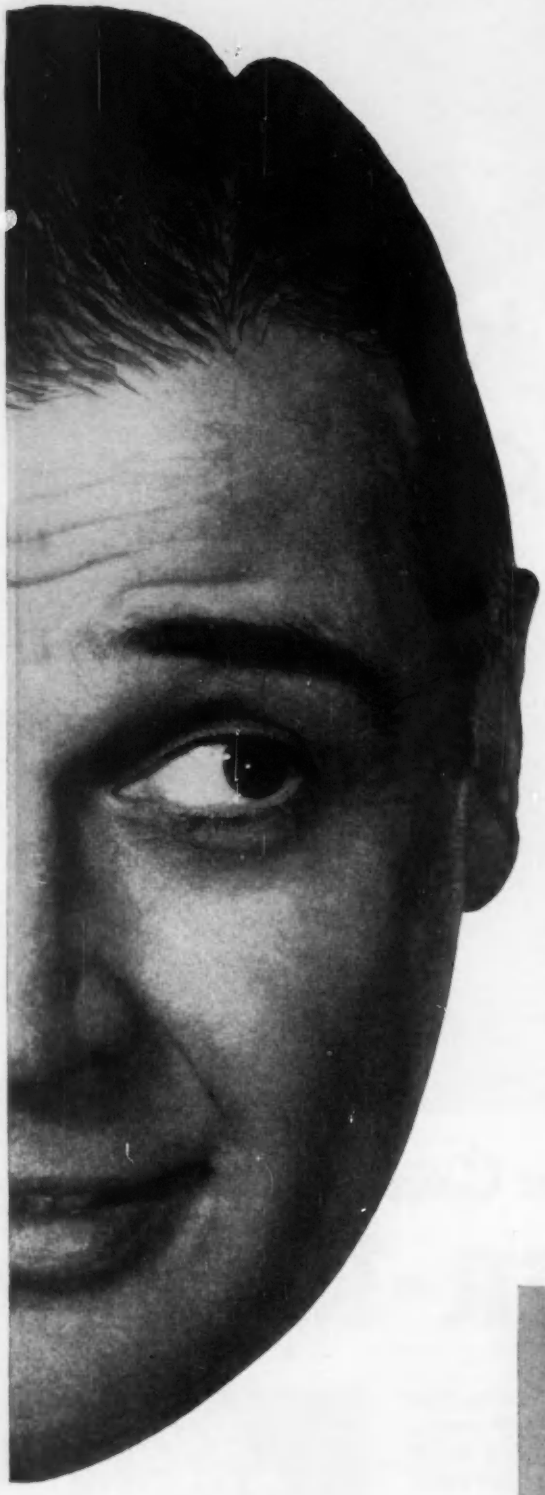


New *Vary-Tally* Multiple-Unit Reset Counter comes in any combination up to 6 banks high, and 12 units wide. Write for news sheet and prices.

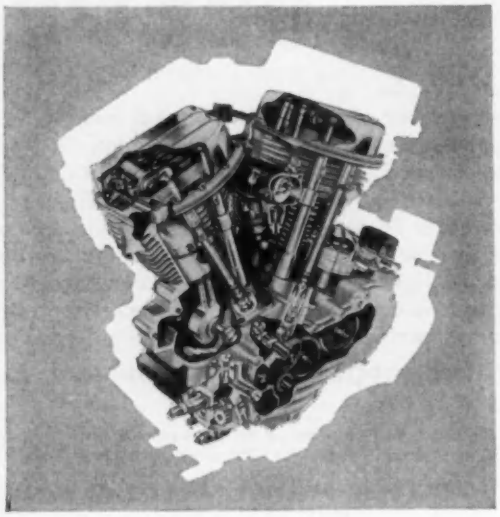
VEEDER-ROOT INCORPORATED • Hartford 2, Connecticut

Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C. • Montreal 2, Canada
Dundee, Scotland • Offices and Agents in Principal Cities

"The Name That Counts"

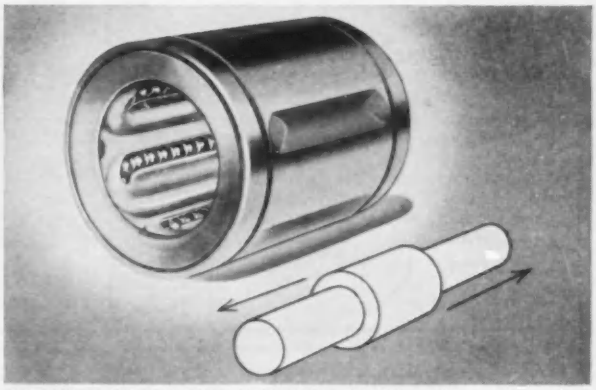


Have you overlooked the big reason for using alloy steels?



When horsepower was increased on the Harley-Davidson motorcycle from 30 to 55, company engineers were faced with designing a transmission that could take the tremendous impact and stress. Republic metallurgists suggested Republic's 8617 Alloy Steel. The result was: reduction of section; good heat treating and carburizing properties; *more horsepower from the same size transmission.*

PAINT REALLY ADHERES to Republic Electro Paintlok sheets. And rust is shut out. That's why these National Biscuit Company truck bodies are made of this zinc-plated steel sheet that's chemically treated to take paints, lacquers, synthetic enamels — and hold them for years. Tight zinc coating guards against underfilm corrosion and creeping rust. Manufacturers of everything from truck bodies to caskets have found production costs go down when they use these special sheets that hold paint longer and make products look better.



ELECTRUNITE CARBON STEEL MECHANICAL TUBING makes some products possible (like this ball bushing for linear motion by Thomson Industries). Problem here was close-tolerance tubing to house bearings and raceway, plus tough wear by bearings at contact points. Republic ELECTRUNITE Tubing supplied all these advantages along with good surface conditions; good dimensional control, both I.D. and O.D.; uniform wall thickness; uniform concentricity; uniformity to withstand heat treating.

A lot of people are under the impression that alloy steels are used only to get certain necessary properties. Heat-treating qualities, for example. Extra fatigue strength. High impact value. High shear resistance. Or many other reasons.

But analysis will show that alloy steels also save money.

There is no better reason for using them. In fact, we don't recommend them unless they do save money, somewhere along the line.

It's just a matter of how much money you want to save. And you save the maximum when you design parts and process properly for alloy steels. That's where we come into the picture. Our 3-D metallurgical service will help you get the properties you want in your products if your engineers and our metallurgists put their heads together.

Let's talk things over now before the competition steps out ahead. A call to your nearest Republic district sales office will get things under way. Have your secretary do it, soon.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

FREEDOM FROM RUST and corrosion makes any product made of Enduro Stainless Steel a good buy. Good example is laundry equipment. Made of stainless steel, it resists rust, corrosion and the action of most washing compounds and detergents. It's easy to keep clean and attractive. And because of resistance to wear, equipment cost can be written off quickly. Republic, pioneer in stainless steel, shows manufacturers how to use it profitably.

REPUBLIC STEEL

REPUBLIC STEEL CORPORATION
3150 East 45th St., Cleveland 27, Ohio

Please send me literature on these Republic products:

☐ Enduro Stainless Steel ☐ Mechanical Tubing
☐ Alloy Steels ☐ Electro Paintlok

Name_____ Title_____

Company_____

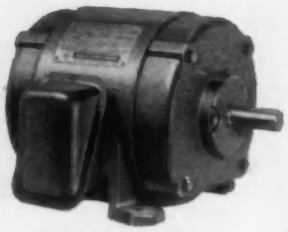
Address_____

City_____ State_____

Mechanical

Where moderate speed range is required and where machine may be stopped to make speed changes. Horsepower range—1½ to 300. Speed adjustment range—9 to 28 percent. Two *Vari-Pitch* sheaves used together double range of adjustment.

Combination starter



Squirrel-cage motor

Vari-Pitch stationary control drive

Mechanical

Where infrequent change of speed in low horsepower drives is required and machine may be stopped for speed adjustment. Especially suitable for fan drives, stokers, small pumps and tools. Horsepower range—fractional to 4 hp. Speed adjustment range—18 to 50 percent. Use of two adjustable sheaves doubles speed adjustment range.

Across-the-line starter

Squirrel-cage motor

Texrope adjustable drive

EIGHT WAYS TO GET VARIABLE SPEED

Electrical

Where stepped speed control is satisfactory. Available with stepless control in larger sizes by using liquid rheostat. Speed is varied by means of control on secondary windings of motor. Horsepower range—5 hp and up. Speed adjustment range—50 percent of synchronous speed to full load speed.

Wound-rotor motor control

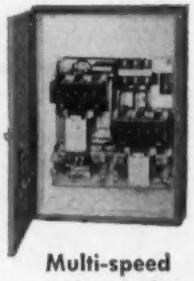
Wound-rotor motor

Texrope V-belt drive

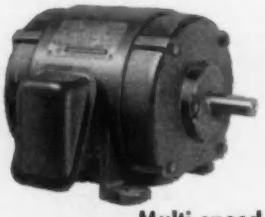
Electrical

Where a few definite speeds are required. Up to four speeds available from one motor. Motor is built on standard squirrel-cage frame with special windings and control. Furnished for variable torque, constant torque and constant horsepower. Horsepower range—½ hp up.

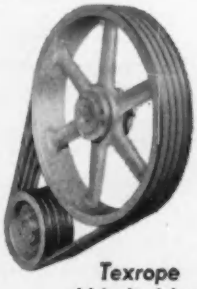
Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.



Multi-speed motor starter



Multi-speed squirrel-cage motor



Texrope V-belt drive

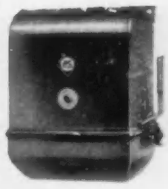
Write for Engineering Literature

A-C ALLIS-CHALMERS

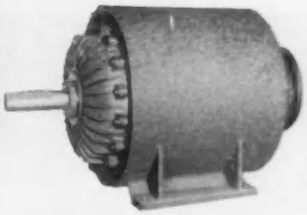
ALLIS-

Mechanical

Where speed must be changed while machine is in motion. Particularly good for machines requiring fine adjustment while operating. Double range of adjustment may be obtained by using two *Vari-Pitch* sheaves. Horsepower range—1½ to 600. Speed adjustment range—9 to 28 percent with one *Vari-Pitch* sheave.



Reduced voltage starter



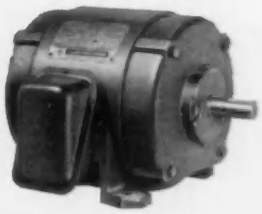
Squirrel-cage motor

Vari-Pitch motion control drive

Mechanical

Where very wide range speed control is required or where enclosed unit is desired. May be manually or remotely controlled. Motor may be mounted on speed changer housing for compact installation. Horsepower range—1½ to 75. Speed adjustment range—3¾ to 1.

Across-the-line starter



Squirrel-cage motor

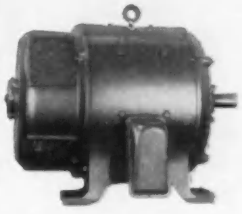
Vari-Pitch speed changer

COMPLETE DRIVES from One Reliable Source

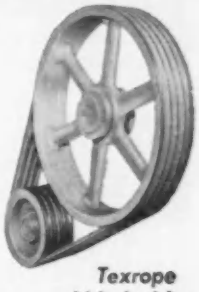
Electrical

Where great versatility is required. Speed may be varied by various types of control, either stepped or stepless. For both constant and variable torque loads. Horsepower range—½ hp up. Speed adjustment range—zero to maximum speed. Maximum speed in smaller sizes, 3500 rpm.

Direct current control



Direct current motor



Texrope V-belt drive

Combination

Where extremely wide range is required, a combination drive adds the speed control range of the motor to that of the *Vari-Pitch* drive. Hundreds of combinations of any of the above units can be worked out to fit the requirements of a particular design.

Wound-rotor motor control

Wound-rotor motor

Vari-Pitch motion control drive

A4523

CHALMERS Milwaukee 1, Wisconsin

Singer's New Slant-Needle Model — First machine that's a cabinet *and* portable all in one. First with the needle slanted to make it easy to see and guide the fabric. Finished in soft beige or traditional black.

How Doehler-Jarvis Helped Singer Develop ...a new way to build precision and make a fine product

Have you seen Singer's new "Slant Needle" Model... the sewing machine designed to make home sewing easier and more convenient?

In one minute it can throw up to 1,500 stitches into your lady's crinolines. It's the only combination portable and cabinet model on the market. (Conversion from one type to the other takes only seconds.) Yet the machine, including motor, weighs under 17 pounds.

Singer can tell you that it's quite a chore to build such features into a machine like this . . . and still keep it competitive. And they're frank to give Doehler-Jarvis major credit for making their job easier with a new method for designing and producing precision parts.

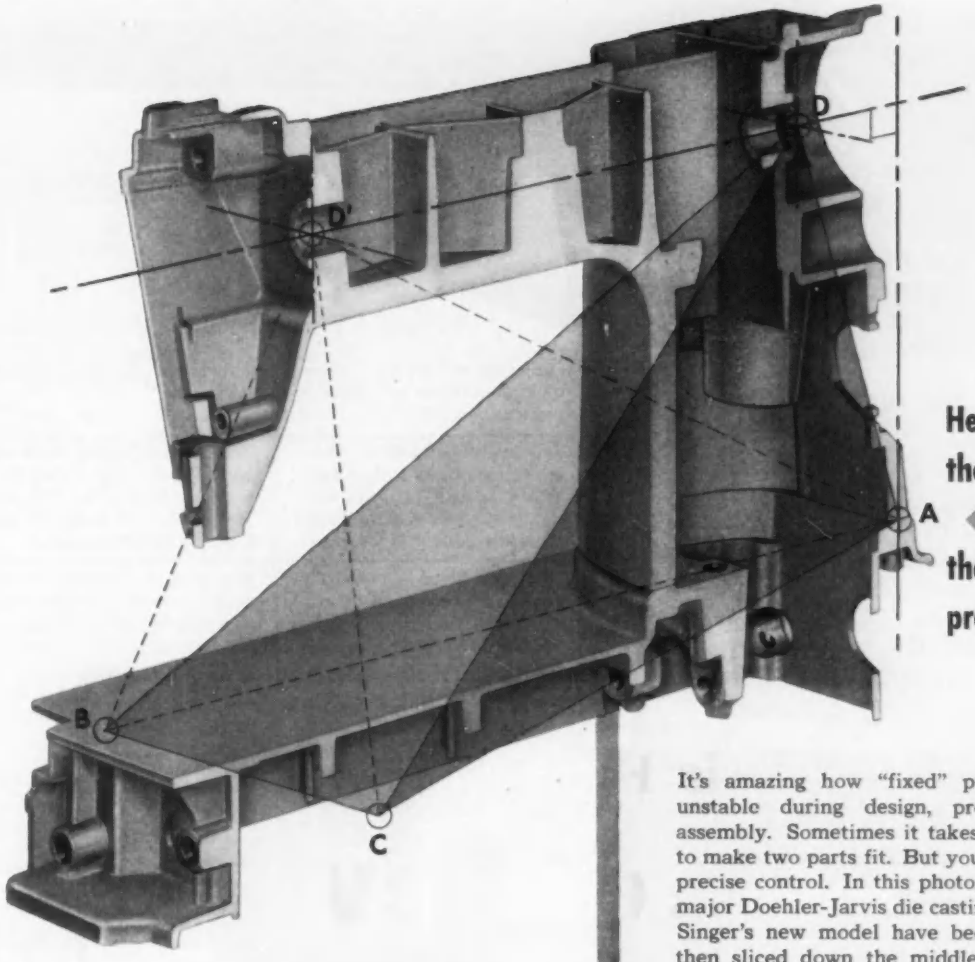
We call this precise new way of making things, "Tripod-Control Dimensioning."

It all started back in '35, when Singer asked Doehler-Jarvis to help pioneer the first die cast aluminum sewing machine components.

To meet the rigid precision requirements, Doehler-Jarvis engineers devised what may have been the first ground and hardened tool-steel casting die ever used. It had its faults, but it did give them machine-tool accuracy. And they discovered the germ of the "Tripod-Control" idea.

What had been discovered was the way to extend a familiar two-dimensional control . . . "baseline dimensioning" . . . to the control of precision in three dimensions. With it they could control precision of and *between* two (or more) die castings of an assembly. They selected a point of vantage common to the parts. Through the point was established a "tripod" of reference from which all critical angles and dimensions could be controlled. Errors vanished. Precision went up . . . assembly troubles down.

Then the idea spread in both the Doehler-Jarvis and the Singer plants. It was used to make multiple gauging jigs . . . used as the basis



Here are the "tripods" that control precision

into parts

finer than ever

It's amazing how "fixed" points become unstable during design, production and assembly. Sometimes it takes manhandling to make two parts fit. But you *can* establish precise control. In this photograph the two major Doehler-Jarvis die castings that frame Singer's new model have been assembled, then sliced down the middle to show the "Tripod-control" method. An imaginary plane of reference, ABC, controls the bed casting dimensions. It passes through point A, a real point of vantage common to both parts. With this plane as a base, imaginary "tripods" are erected to "fix" the plane ADD' and control arm-casting dimensions. The same planes control precision measurements in all following operations.

for ganged machining . . . used in finishing . . . used in assembly.

By the time the "Slant Needle" model came along, "Tripod-Control Dimensioning" had grown to a full-fledged design and production technique . . . based on die castings . . . used even in the first rough sketches of the new product . . . used in the planning stages . . . used throughout tooling and production.

Today? Well . . . you never saw production flow more smoothly when complex precision parts are made by one company, finished and assembled by another.

In its half century of die casting, Doehler-Jarvis has helped many producers, large and small, find the best way to take full advantage of die casting techniques . . . among them some of the best known makers of automotive, electrical, communication, household, office and other types of equipment.

Doehler-Jarvis Division

of

National Lead Company

General Offices: Toledo 1, Ohio

* Reg. U.S. Pat. Off.

When they come to Doehler-Jarvis, they know that Doehler-Jarvis can supply both the resources and the resourcefulness they need.

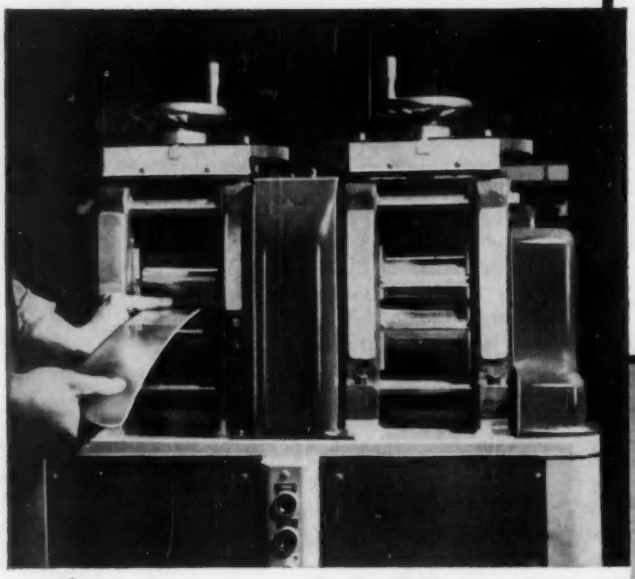
So next time you have a new product on the boards . . . call Doehler-Jarvis in on the design and production engineering. We may be able to give you just the solid kind of help you're looking for.

The MEEHANITE Casting Reporter

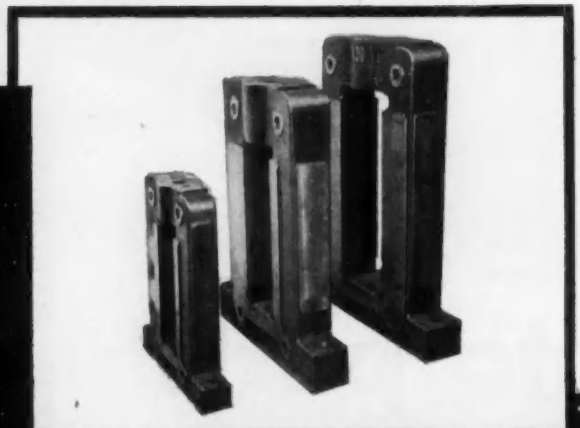
3 PROBLEMS SOLVED IN STANAT MILLS

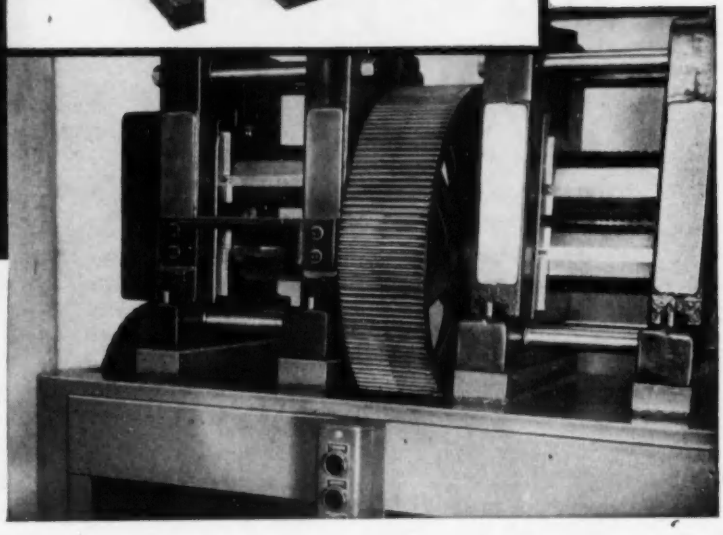
The Stanat Manufacturing Company, Long Island City, New York, produce a line of small rolling mills used in both laboratory and industrial production. Three fundamental problems in the design and manufacture of these mills were encountered and solved as follows:

	PROBLEM	SOLUTION
1.	Subjection of frames to unpredictable stresses and shock in service.	Strong, tough, rigid Meehanite frames.
2.	Roll leveler—a unit for leveling strip stock up to 3/16" thick. Wide speed ranges and changing types of material impose intermittent shock loads.	Pressure lubrication achieved by rifle drilling Meehanite frames. Meehanite housings for pinch roll bearings for long life and soundness.
3.	Bull gear breakage—an unexpected application by customer resulted in gear breakage.	Bull gear redesigned to use heat treated Meehanite castings. No further breakage.



↑ Stanat three-inch combination mill assembled for rolling both flat and wire stock.





Heat treated Meehanite bull gears eliminated breakage in service. →

BUILDER SAYS:

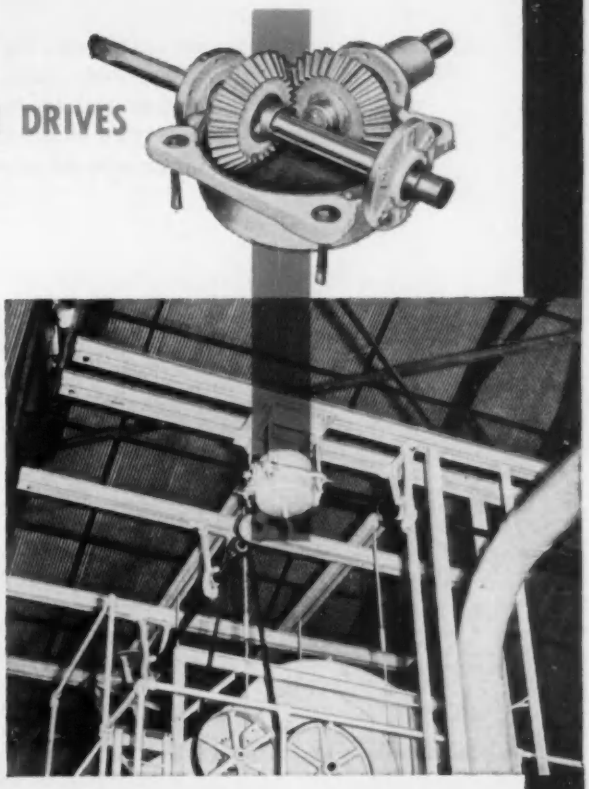
"Generally, we use Meehanite castings for parts subject to high stress, heavy shock loading or where we desire dimensional stability during machining. Also, we use special heat treatable types of Meehanite metal in applications such as gears, and for rolls used in our mills for hot rolling.

The use of the Meehanite castings gives us greater design freedom, makes for more compact sizes and gives a product that we know will stand up to anything that can be reasonably be asked of a mill."

WHAT MEEHANITE CASTINGS HAVE DONE FOR THEM

MEEHANITE GEARS

REPLACE FORGED STEEL IN COTTON GIN DRIVES



The Lummus Cotton Gin Company, Columbus, Georgia, achieved major machining and material economies by specifying Meehanite gear blanks when manufacturing the drive mechanism shown.

Formerly cut from a solid forged steel billet, redesign, after a study of the engineering properties available in Meehanite metal, developed a gear blank from which the drive gears were machined.

The unit as indicated, is a drive for a tramper countershaft on a cotton gin and operates not only the tramper, but in some cases, hydraulic pumps for the presses and is driven by a 30 HP motor.

BUILDER SAYS:

"We thus achieved not only a substantial saving in machining time and material, but operational noise was reduced because of the high vibration damping quality of the Meehanite gears."

ONLY A MEEHANITE FOUNDRY CAN MAKE MEEHANITE CASTINGS

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington and Dover, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry	Providence, Rhode Island
Compton Foundry	Compton, Calif.
Continental Gin Co.	Birmingham, Alabama
Crawford & Doherty Foundry Co.	Portland, Oregon
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio & Grove City, Pa.
DeLaval Steam Turbine Co.	Trenton, New Jersey
M. H. Detrick Co.	Newark, N. J. and Peoria, Ill.
Empire Pattern & Foundry Co.	Tulsa, Oklahoma
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Georgia Iron Works Co.	Augusta, Ga.
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Hardinge Company, Inc.	New York, New York
Hardinge Manufacturing Co.	York, Pennsylvania
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
Palmyra Foundry Co., Inc.	Palmyra, New Jersey
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Prescott Co.	Menominee, Michigan
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Sonith Industries, Inc.	Indianapolis, Ind.
Southern Illinois Foundry Co.	Carmi, Ill.
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Company	Oakland, California
Washington Iron Works	Seattle, Washington

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Hartley Foundry Division— London Concrete Machinery Co., Ltd.	Brantford, Ontario
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Write for your copy of "The Handbook of Meehanite Metals"

This Advertisement Sponsored by Foundries listed above

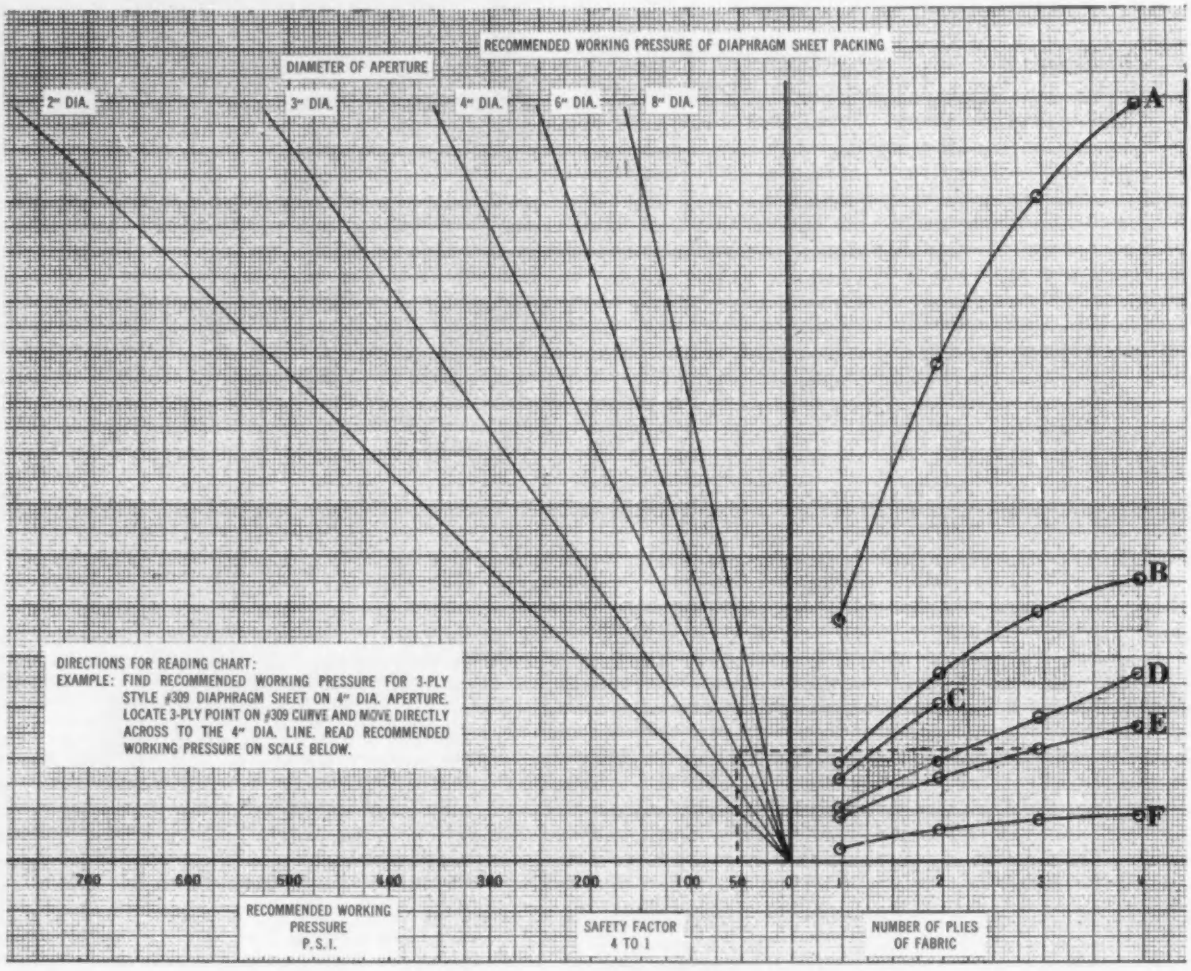
MEEHANITE METAL® CORP.

714 North Ave., New Rochelle, N. Y.

This United States Rubber Company Chart

will help design engineers specify the proper diaphragm sheet packings

This valuable chart shows at a glance the recommended working pressures of the most widely used diaphragm sheets. Crude rubber covers are recommended for water, air, steam and dry natural gases; Neoprene covers for mineral oils; Buna N covers for all services especially where diffusion is a problem. Send for your *free enlarged reproduction*. Write to address below.



A. NYLON-P-2902 (CRUDE RUBBER) P-2903 (BUNA N) P-2904 (NEOPRENE)

B. COTTON-P-2139 (CRUDE RUBBER) P-2141 (NEOPRENE)

C. NYLON-P-2339 (CRUDE RUBBER) P-2341 (BUNA N) P-2905 (NEOPRENE)

D. COTTON-#509 (CRUDE RUBBER) P-2133 (NEOPRENE)

E. COTTON-#309 (CRUDE RUBBER) P-2135 (NEOPRENE)

F. COTTON-P-2136 (CRUDE RUBBER) P-2138 (NEOPRENE) 1516-F (CRUDE RUBBER) P-2335 (BUNA N) P-2901 (NEOPRENE)

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

Hydraulic Diaphragm Sheet Packing by U.S. Rubber

U.S. Duck Inserted Diaphragm Sheet Packing

Style No. 309—*crude rubber cover*. General purpose packing, with medium-weight duck inserted between covers of high-grade rubber compound. For packing reducing valves and regulators of all types.

Style No. 509—*crude rubber cover*. Recommended for reducing valves and regulators of all types. High tensile square-woven duck gives structural strength over entire area. Furnished 46″ wide, 1/16″ thick and up.

Style No. P-2133—*Neoprene cover*. Impervious to action of cold oils and gasoline. High-quality medium-weight duck insertion. Furnished 46″ wide, 1/16″ thick and up.

Style No. P-2135—*Neoprene cover*. Oil-resistant, with lightweight duck insertion. Furnished 46″ wide, 1/16″ thick and up.

U.S. Sheeting Inserted Supersensitive Diaphragm Packing

Style No. 1516-F—*crude rubber cover*. Especially recommended for low-pressure conditions where supersensitiveness is essential or desirable. It has exceptional flexibility and is extremely sensitive and responsive to the slightest change in pressure. The bursting strength across a 2″ circular opening in the 1/32″ thickness is about 45 pounds, and in the 1/16″ thickness about 67 pounds, per square inch. Furnished in rolls of 100 and 200 pounds, 36″ wide, in 1/32″, 1/16″, 3/32″, 1/8″ and 3/16″ thickness.

Style No. P-2136—*crude rubber cover*. Has sheeting insertion, in 36″ width only, 1/32″ thick and up.

Style No. P-2138—*Neoprene cover*, with sheeting insertion, in 36″ width only, 1/32″ thick and up.

Style No. P-2335—*Buna N cover* with special sheeting insertion. 36″ wide, 1/32″ thick and up.

Style No. P-2901—*Neoprene cover* with sheeting insertion, recommended for handling oils and solvents; 36″ wide, 1/32″ thick and up.

Style No. P-2139—*crude rubber cover* with extra-heavy duck insertion, 1/8″ thick and up.

Style No. P-2141—*Neoprene cover*. Oil-resistant, with extra-heavy duck insertion, 1/8″ thick and up.

U.S. Nylon Inserted General Service Diaphragm Sheet Packings

Style No. P-2902—*crude rubber cover*. General service diaphragm sheet; supplied in 40″ widths of 1/16″, 1/8″, 3/16″ and 1/4″ thicknesses.

Style No. P-2903—*Buna N cover*. General service diaphragm sheet. Supplied in 40″ widths of 1/16″, 1/8″, 3/16″ and 1/4″ thicknesses.

Style No. P-2904—*Neoprene cover*. General service diaphragm sheet. Supplied in 40″ widths of 1/16″, 1/8″, 3/16″ and 1/4″ thicknesses.

U.S. Nylon Inserted Supersensitive Diaphragm Sheet Packings

recommended for high pressures

Style No. P-2339—*crude rubber cover* with supersensitive diaphragm sheet. Supplied in 36″ widths in 1/32″, 1/16″ and 1/8″ thicknesses.

Style No. P-2341—*Buna N cover*. Supersensitive diaphragm sheet; supplied in 36″ widths of 1/32″, 1/16″ and 1/8″ thicknesses.

Style No. P-2905—*Neoprene cover*. Supersensitive diaphragm sheet; supplied in 36″ widths of 1/32″, 1/16″ and 1/8″ thicknesses.

UNITED STATES RUBBER COMPANY manufactures a complete line of diaphragm sheets for a wide variety of hydraulic service conditions. U. S. Packings and engineering service are obtainable at any of the 27 "U.S." District Sales offices or by writing address below.

"U.S." Research perfects it
"U.S." Production builds it
U.S. Industry depends on it

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION · ROCKEFELLER CENTER, NEW YORK 20, N. Y.

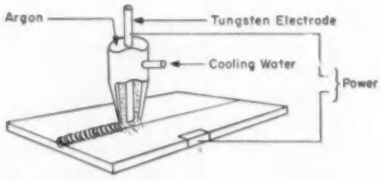
US RUBBER

3 Modern Methods

BOOST...

- Production
- Profits
- Quality

Whatever your fabricating needs—in small shops or on production lines, on carbon steel, complex alloys or non-ferrous materials —LINDE has a high-speed, cost-saving electric welding process for every job. Here is the line-up of this top-notch team...



HELIARC Welding—*ideal for metals .020 in. and thicker* . . . Joins all commercial metals in easy operations—attains speeds over 100 inches per minute . . . Welding is done in all positions on all types of joints with portable manual, semi-automatic, and mechanized equipment.

There is no slag, spatter, or smoke—the operator can see and control the weld puddle at all times. Weld finishing is seldom necessary, and investment and maintenance costs are low.

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY
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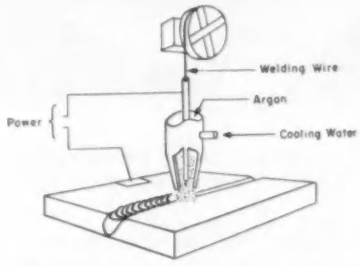
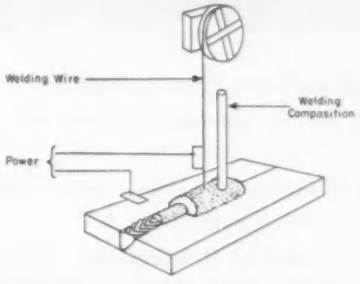
Linde Trade-Mark

For Joining Metals.....





Sigma Welding—*4 times faster wire deposition than by manual rod feed methods* . . . Full penetration up to ¼-in. in a single pass . . . Joins all commercial metals —and attains speeds of more than 100 inches per minute on many operations.

Uses any d.c., or c.p. (constant potential) power supply. With c.p., an operator has only to set the wire feed rate—current remains essentially constant throughout welding. Both manual and automatic mechanized sigma welding equipment is easy to operate and maintain.

UNIONMELT Welding—*joins metal of any thickness . . . Up to 3-in. thick in one pass.* Extreme depth of penetration and high rate of wire feed make this the fastest and usually the most economical of all welding processes. Deep penetration or wide shallow beads are easily attained by UNIONMELT welding.

Both portable manual and mechanized setups are available, and can use any a.c., d.c., or c.p. (constant potential) power supply. With c.p., no control is necessary to maintain constant arc voltage throughout welding.

Start Saving Now — Call Your Local LINDE Representative Today . . .

Ask for Form 7942, "Modern Methods of Joining Metals."

KLIXON

Thermo Snap®

TEMPERATURE CONTROLS

"... Insure service-free operation in the numerous models in our lines of Gas Appliances"

Says Mr. Howard Bourner, Temco Design Consultant

The Temco Dryer, illustrated, is quality designed to give maximum drying efficiency plus exceptionally long life.

To insure accurate temperature control, Temco uses Klixon Thermo-Snap Controls in their units.

Here's what Mr. Howard Bourner, Temco Design Consultant, has to say about Klixon Controls...

"We have used thousands of Klixon switches on our clothes dryers, space heaters, wall furnaces and fan heaters, and, over a wide range of applications, we have found these thermostats thoroughly dependable. In order to insure service-free operation of the numerous models in our line of gas appliances, we use Klixon switches."

They are available in many hermetically sealed and open types in a wide variety of operating temperature ranges.

Klixon Engineers, specialists in temperature control applications, can help solve your specific problems. Write for their help or further information.

You, too, can benefit by using Klixon Thermo-Snap Temperature Controls.

Typical Klixon Thermo-Snap Controls that can help you solve your Thermostat Control Problems

KLIXON

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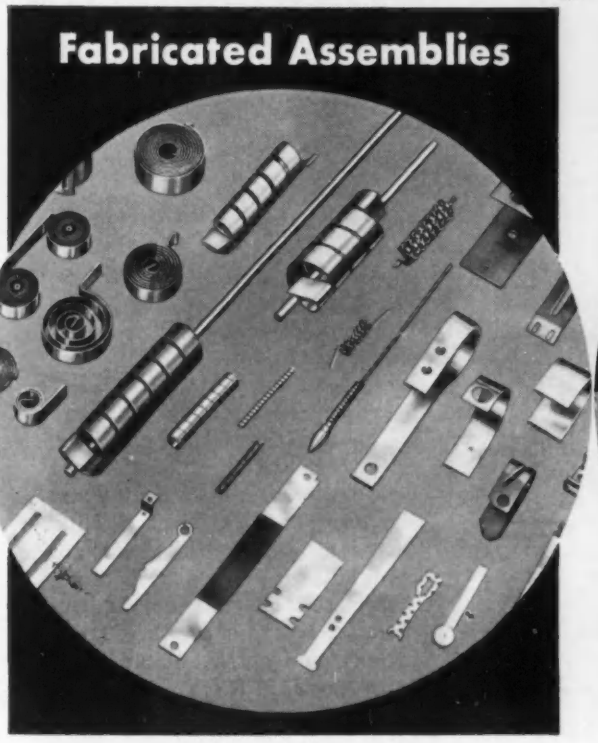
METALS AND CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
902 FOREST STREET, ATTLEBORO, MASS.

In Any Form



General Plate TRUFLEX® Thermostat Metals

Give Accurate Temperature Response . . . Cut Costs

General Plate *Truflex* Thermostat Metals provide a sure way to get reliable performance and at the same time cut costs of products requiring temperature control, indication or compensation.

Advanced General Plate production methods coupled with the best equipment available insure close tolerances on all properties and dimensions. This maintains positive consistency in thermal, mechanical, and electrical performance. With no variation from lot to lot rejects are eliminated, costly adjustments are minimized.

General Plate *Truflex* fabricated assemblies are engineered and manufactured to your specifications, ready for installation into your products. They eliminate costly fabrication problems . . . needless special equipment . . . experimental work and expensive calibration.

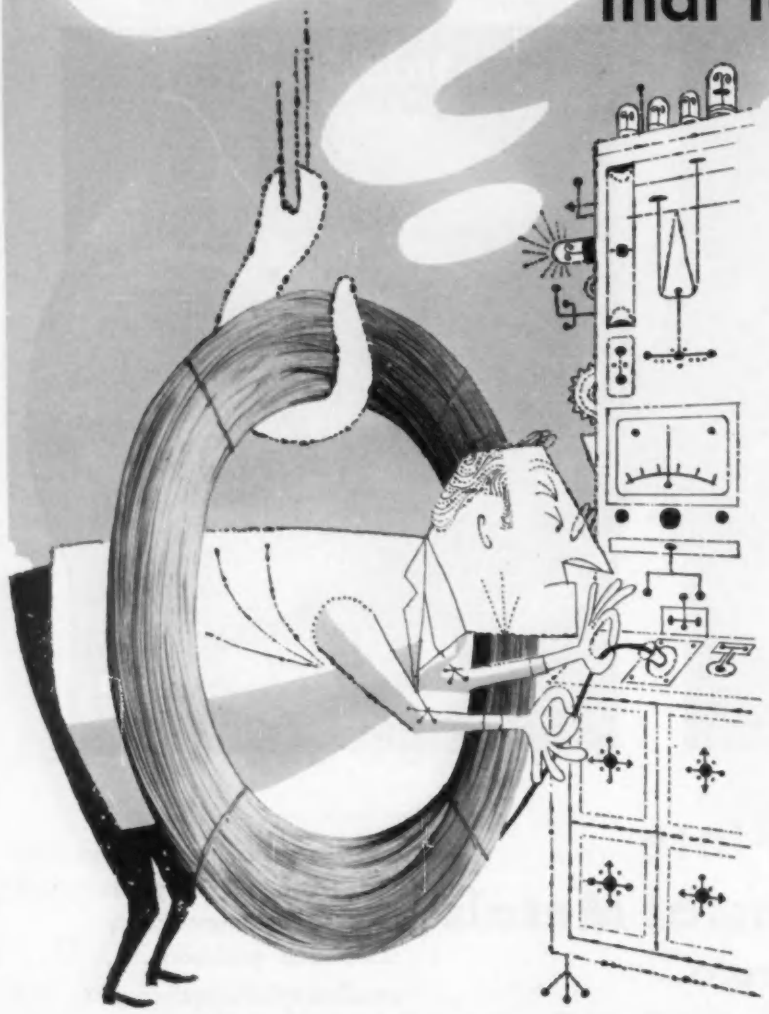
However, if you prefer to make your own assemblies, General Plate *Truflex* Thermostat Metals are available as strip in extra long coils or flat cut lengths manufactured to your material specifications.

Write for information and engineering assistance.

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
12 FOREST STREET, ATTLEBORO, MASS.

Do you design machinery that fabricates wire?



The design of Wire Fabricating machinery is one of the most rigorous engineering assignments you can get. But no matter how tricky the problems, do not forget the front end of the machine—where you actually load the wire.

We have been amazed, for example, to learn that certain customers have been buying non-standard coils of wire for years, thinking that they were *standard* coils. Naturally, there is a shipping delay due to not being able to use standard material.

Here's an offer: If you contemplate the design of any wire fabricating equipment, get in touch with your American Steel & Wire representative first. Let him bring you up to date on the latest wire industry standards—and show you how to design the equipment to use the most economical types and sizes of wire coils. He will also be glad to help you lay out your wire storage and handling facilities. The result will be lower costs and faster delivery and better production using your newly designed equipment.

USS AMERICAN MANUFACTURERS WIRE

AMERICAN MANUFACTURERS WIRE

AMERFINE—*High quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire*

USS TRADE MARK

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
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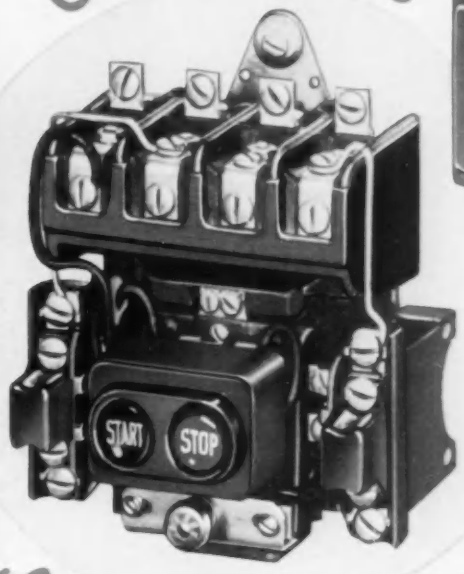
UNITED STATES STEEL

BULLETIN 609—
Max Rating: 5 hp,
220 v; 7½ hp,
440-550 v.

Manual or Automatic

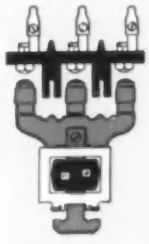
Bulletin 609

BULLETIN 709—
In 8 sizes up to 300 hp, 220 v; 600 hp, 440-550 v.

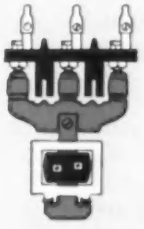


Bulletin 709—Form I

CONTACTOR OPEN



CONTACTOR CLOSED



DOUBLE BREAK, SILVER ALLOY CONTACTS

The silver alloy used for Allen-Bradley double break contacts remains always in perfect working condition. Hence, there is no need for contact maintenance. You can install an A-B starter and forget it.

The MOST POPULAR MOTOR STARTERS Trouble Free . . . No Contact Maintenance

These two Allen-Bradley across-the-line motor starters . . . Bulletin 609 manual and Bulletin 709 magnetic . . . enjoy world-wide popularity because no matter what the service may be, they will not fail.

Both starters are simple, assuring long, trouble-free life. Both provide dependable overload protection to the motor. Both are push-button operated . . . one, mechanically through a snap-action linkage, and the other, electrically with a solenoid plunger.

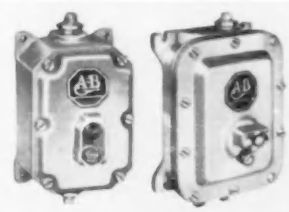
For continuous plant operation, specify either Bulletin 609 manual or Bulletin 709 solenoid starters. For maximum protection to man, motor, and machine, the Bulletin 709 is best. Its "no-voltage" protective feature prevents accidental restarting of motors after power interruptions. Write for the A-B Handy Catalog —6th Edition.

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.

•

In Canada—
Allen-Bradley Canada Ltd., Galt, Ont.

ENCLOSURES for Every Operating Condition



NEMA type enclosures are available for Bulletin 609 and Bulletin 709 starters to satisfy any operating requirement.

ALLEN-BRADLEY

MANUAL AND AUTOMATIC STARTERS

QUALITY

2-55-RM

A QUALITY STARTING SWITCH for SMALL MOTORS

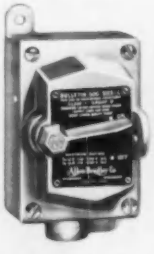
Providing Reliable Overload Protection

With linkage lever & pilot light.

With standard lever & pilot light.

3-Way selector & pilot light.

With removable key switch.



NEMA Type 7 enclosure for hazardous dust or gas conditions.

NEMA Type 4 enclosure for watertight & weatherproof service.

BULLETIN 600 MANUAL STARTER

for Motors of 1 Hp or less

This compact toggle switch with a built-in overload breaker satisfies the National Electrical Code (Para. 4322 sub. C) covering overload protection requirements for motors of 1 hp or less.

QUICK MAKE & BREAK CONTACTS—The simple, rugged, over-center mechanism has a quick make and break action. No "teasing" of contacts means long contact life.

GENEROUS WIRING SPACE—Cover slips off, exposing front and both sides.

ATTRACTIVE APPEARANCE—The clean, modern lines are a sales asset to any machine. Enclosures listed for every service.

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.

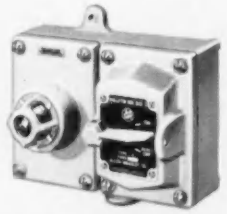
In Canada—
Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
TROUBLE FREE MOTOR CONTROL
QUALITY

Flush mounting of two Bulletin 600 starters, each with a pilot light.

In a standard switch box.

In a surface mounted box.



NEMA Type 4 enclosure with pilot light for use in wet locations.

2-55-RM

Looking for a Stainless Steel with a *New* combination of properties?

Here is a radically different chrome-nickel stainless developed by Carpenter to give you this unusual combination of fabricating and product benefits . . .

. . . work hardens *much slower* than any of the conventional 18-8 grades

. . . remains *non-magnetic* after severe cold working

. . . possesses corrosion resistance *equal to or better than* standard chrome-nickel stainless steels

This unusual combination of advantages is one reason why Carpenter *Stainless No. 10* is earning a unique place among engineered materials.

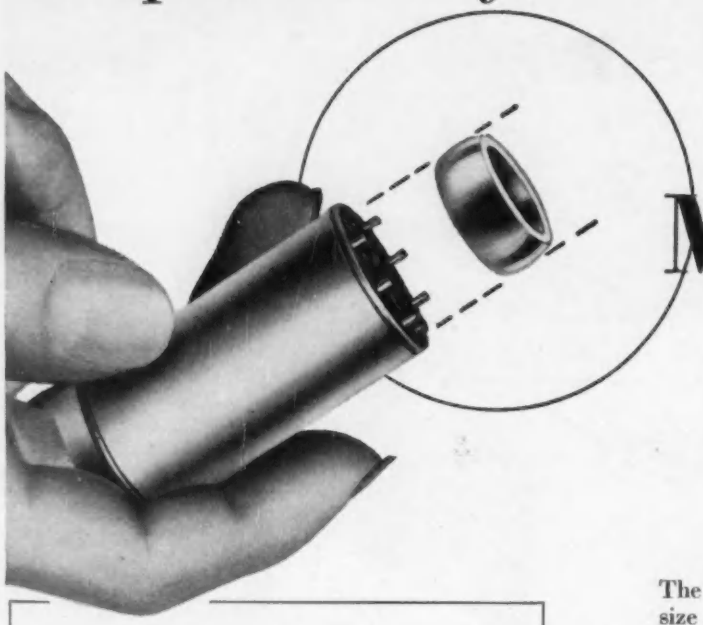
For example, it has opened whole new fields of applications in the fastener industry. With its slower work-hardening, fastener manufacturers can now produce on automatic machines severely cold headed and upset chrome-nickel stainless parts without process annealing. *No. 10* is also proving its economy on other jobs involving difficult coining, extrusion and swaging operations.

Another example is instrument parts which must remain non-magnetic after fabrication. After a 50% reduction, with a field of 200 Oersteds, permeability is about 1.002. After an 80% reduction: about 1.018. Will you be *next* to benefit from *Stainless No. 10?* How can *your* stainless product be improved, production simplified, costs lowered? Get the complete story on *No. 10.* Just drop us a line on your Company letterhead. THE CARPENTER STEEL CO., 117 W. Bern St., Reading, Pa.

Carpenter STEEL — Stainless No. 10 — *take the problems out of production.*

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research
Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Compact rotor for miniature gyroscope



made with

MALLORY 1000 METAL

The secret of this sub-miniature gyroscope's extra-small size is a tiny rotor made of Mallory 1000 Metal. Hardly as big as a wedding ring, this rotor provides exceptionally high inertia . . . operates at high rotational speed that gives the gyro greater sensitivity than previously possible.

Twice as dense as steel or brass, and far stronger than lead, Mallory 1000 supplies designers with the ideal answer to the problem of getting large mass into small space . . . in counterweights, rotors and similar mechanical parts.

Mallory 1000 has excellent machinability. Surface finishes of 10 to 40 microinches are readily obtained. To save production costs, you can take advantage of Mallory's exclusive contour pressing methods which produce intricate shapes to precise dimensions.

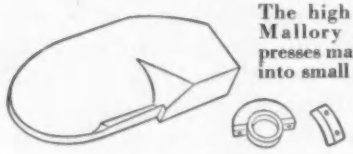
Write to Mallory today for Technical Bulletin 6-7 for complete data.

Highly Uniform Physical Properties

Mallory 1000 is made to high standards of uniformity. The properties specified can be relied upon as applying to all parts produced, and not simply representative or "typical" properties.

	Average	Minimum
Density (parts up to 2500 grams)	16.96 gm/cc	16.71 gm/cc
Tensile strength (ultimate)	112,000 psi	94,000 psi
Modulus of rupture (simple beam, center loaded)	220,000 psi	180,000 psi
Elongation (% in 2")		2%

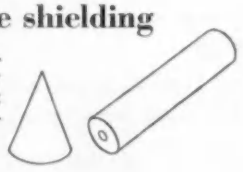
Smaller counterweights



The high density of Mallory 1000 compresses maximum mass into small volume.

Effective shielding

Up to 40% more efficient than lead, Mallory 1000 is an excellent material for radioactive shielding.



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Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

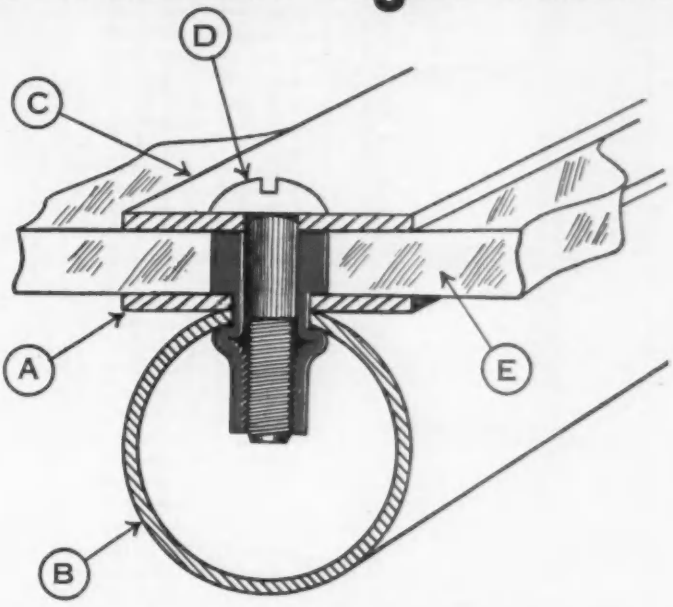
For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

B. F. Goodrich **RIVNUTS** fasten plastic to tubular post, make weather-tight seal!

TO PROVIDE a neat, tight seal for airplane windows, designers needed a simple, one-piece fastener—a blind rivet and nut plate combined. They found the ideal answer in a spacer-head B. F. Goodrich Rivnut.

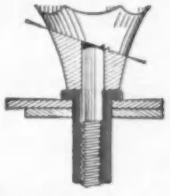
With the easy-to-use heading tool, one man quickly upset the Rivnut, securely riveted plate "A" to tubular center post "B". The firm bulge formed in the Rivnut shank conformed to the curvature of the tube. The Rivnut head served as a spacer for transparent plastic sheets "E". Screw "D" was then threaded into the clean, still-intact Rivnut threads to hold clamp strip "C" and plastic sheets in place.

Besides providing a tight, dependable seal, Rivnuts saved many man-hours on this job. If you're looking for a fastener which can improve your product and cut production time, why not get the facts from a Rivnut engineer? Write The B. F. Goodrich Company, Department PE-25, Akron, Ohio.

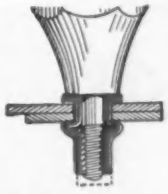


Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.



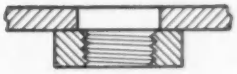
3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

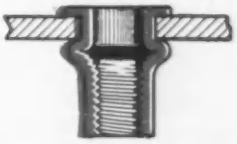
Compare these 4 methods of putting screw threads in thin sheet metal

Tapped—2 threads

Pierced and tapped—3 threads



Projection welded—4 threads



Rivnut—at least 6 threads

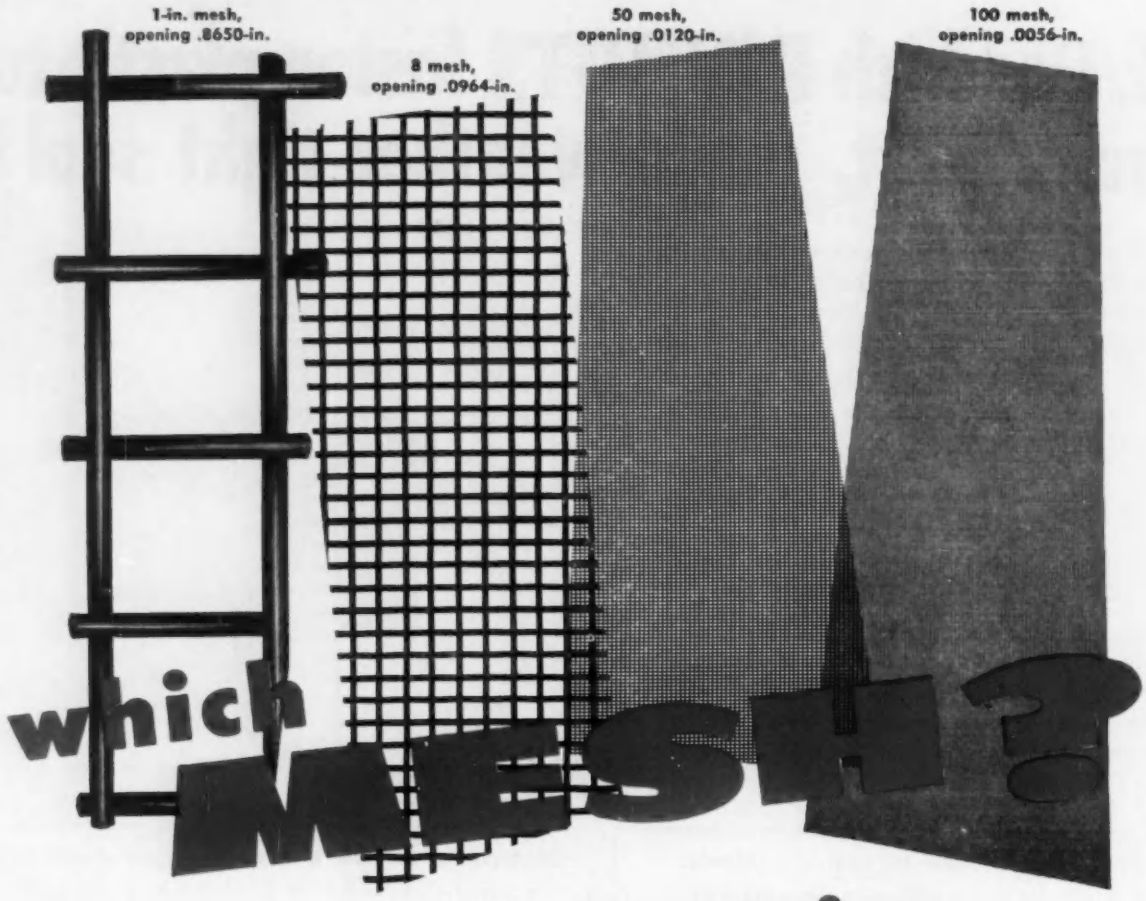
B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Shows with motion how Rivnuts work. Explains construction, gives proved applications. Write to The B. F. Goodrich Co., Dept. PE-25, Akron, Ohio.



...or wire
...or weave
...or metal

Mesh is the number of openings per lineal inch, measured from the center of any wire. It is only *one* of many factors to be determined in finding the right industrial wire cloth to fit precisely the job it must do in your product.

Then there's the question of the gauge, metal or alloy, and coating of the wire. The weave, weight, strength, flexibility, resistance to atmospheric and chemical corrosion of the cloth itself. And more.

If it is Reynolds industrial wire cloth it will be *right*—precision processed to your specifications.

Or, if you have wire cloth problems, Reynolds Engineers are ready to help you find the right answer.

Details in Sweet's product design file.

Reynolds WIRE CLOTH for Industry

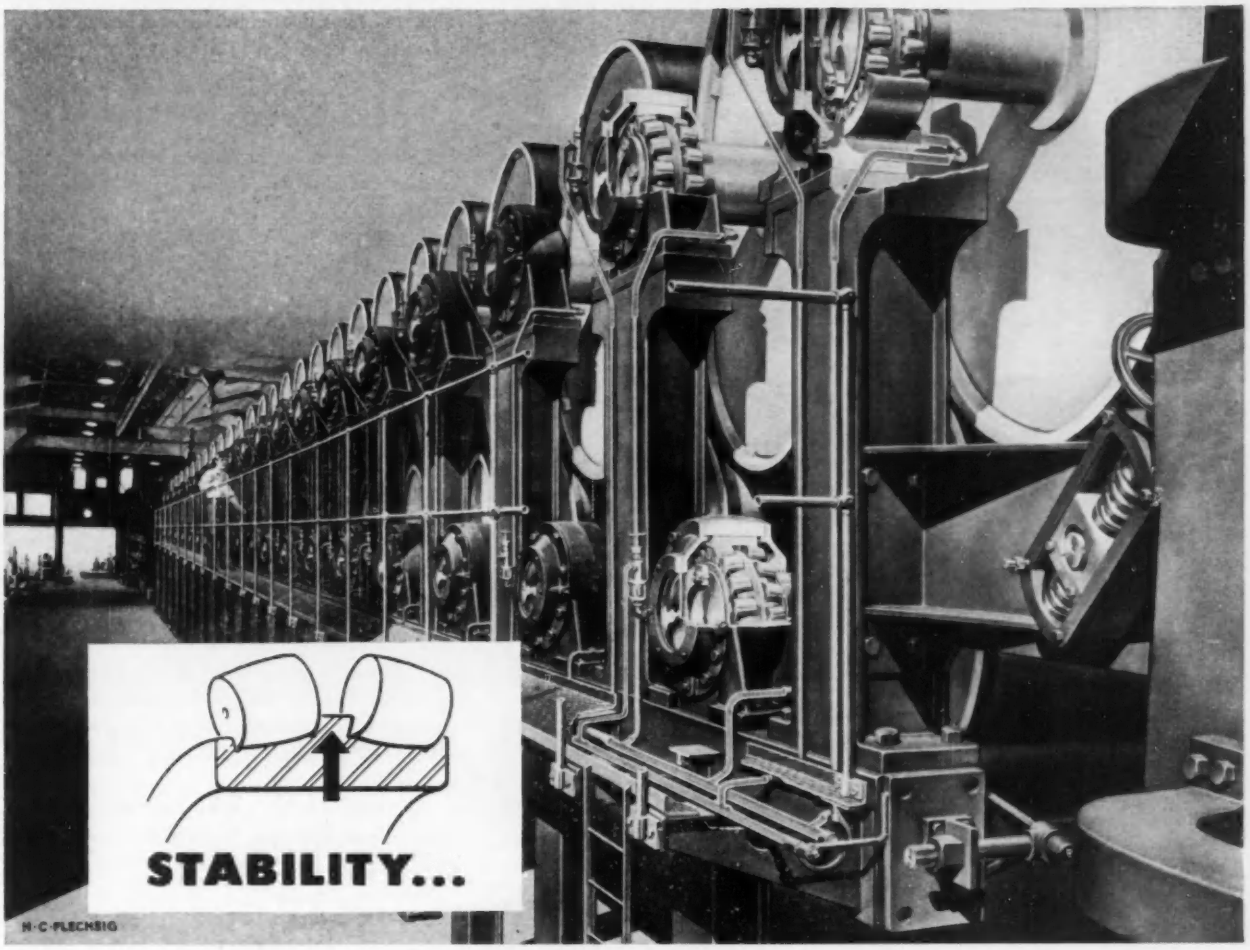
NS NATIONAL-STANDARD Company NILES MICHIGAN

REYNOLDS WIRE DIVISION, NATIONAL-STANDARD CO., Box 200, **DIXON, ILL.**

Divisions of National-Standard Co.

ATHENIA STEEL...*Clifton, N. J.*.....Flat, High Carbon, Cold Rolled Spring Steel
NATIONAL-STANDARD...*Niles, Mich.*.....Tire Wire, Fabricated Braids and Tape
WAGNER LITHO MACHINERY...*Jersey City, N. J.*.....Metal Decorating Equipment
WORCESTER WIRE WORKS...*Worcester, Mass.*...Round and Shaped Steel Wire, Small Sizes

TORRINGTON *Spherical Roller Bearings are used in every kind of heavy duty application requiring high load capacity, resistance to shock and wear under conditions of misalignment.*



TORRINGTON Spherical Roller Bearings

are designed with integral center flange on inner race to provide positive radial stability and positioning for thrust loads

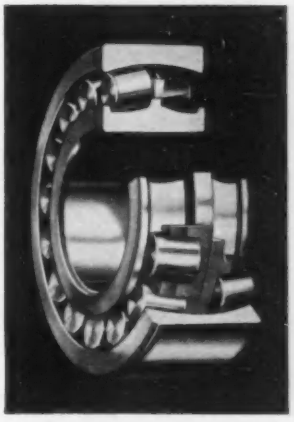
This center flange guides the rollers accurately and friction is reduced to a minimum.

Other performance-building features include accurate geometrical conformity between races and rollers to provide ultimate load carrying capacity; carefully heat-treated races and rollers for maximum resistance to shock and wear; one-piece machined bronze cage for each path of rollers to allow thorough lubrication and give freedom of operation.

These are some of the reasons why TORRINGTON SPHERICAL ROLLER BEARINGS give long, satisfactory performance.

TORRINGTON SPHERICAL ROLLER BEARINGS are available from stock with either straight or tapered bore, for shaft or adapter mounting.

Specify TORRINGTON and get these operational advantages in your equipment.



THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON SPHERICAL ROLLER BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

AlSiMag®
PRESSED CERAMICS ARE
Versatile!

Volume. Batteries of presses . . . rotaries, single stroke, U. S. and foreign. Enormous kiln capacity. 4 large, well-equipped plants.

Experience. Methods which have been perfected from 54 years of specialized experience.

Resign service. Available without charge. Every effort made to find the best design . . . performance-wise and economy-wise.

Selection of materials. Widest in the industry. Careful matching with requirements. New bodies being developed constantly for unusual operating conditions.

Applications determine the material. You may choose from Lava, Silicon Carbide, Alumina (vitrified or porous), Cordierite, Steatite, Zircon, Zirconium Oxide, Magnesium Silicate, Aluminum Silicate, Forsterite, Titanium Dioxide. All available from this one source.

Tooling. No problem with AlSiMag. Well equipped die shops. Expert machinists. Tooling at actual estimated cost.

Intricate Designs. AlSiMag's over-all delivery record is unsurpassed . . . complicated shapes, precision tolerances, intricate miniatures.

Low Cost. Superior quality. Achieved through the right equipment . . . right materials . . . all-important "know-how."

Efficient production methods. Quality controlled manufacture. Well experienced, versatile personnel.

• AlSiMag may offer improvements for your application. Send in blueprint or sample today for price and delivery information.

53RD YEAR OF CERAMIC LEADERSHIP

AMERICAN LAVA CORPORATION

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A SUBSIDIARY OF MINNESOTA MINING AND MANUFACTURING COMPANY

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HYDRAULICS FOR MOBILE EQUIPMENT

VOL. 2

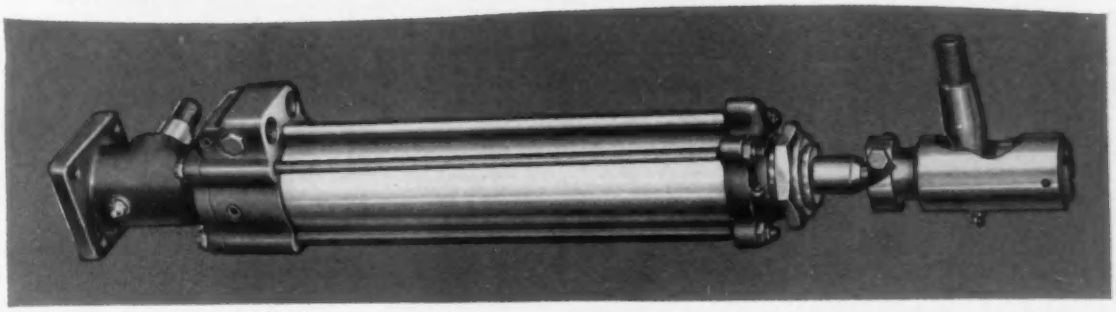
Mobile Equipment News

VICKERS INCORPORATED, DETROIT, MICHIGAN

IMPROVES PERFORMANCE & CUTS COSTS

NO. 5

New! VICKERS® HYDRAULIC POWER STEERING BOOSTER...SERIES S23



LATEST DEVELOPMENT in POWER STEERING for TRUCKS, BUSES, MATERIALS HANDLING VEHICLES, ROAD CONSTRUCTION and MINING MACHINERY

More compact . . . improved in operating characteristics . . . this new Vickers Steering Booster, Series S23 is an important new development in power steering for many vehicles. Application is much easier because it requires less space . . . and ultimate costs are substantially lower. Series S23 thus opens the way to fingertip ease of steering for a wide range of additional vehicles.

Like the preceding models, Series S23 has hydraulic lock against road shock. Bumps, chuckholes, blown front tires, obstructions, etc., cannot spin the steering wheel or jerk it out of control. This is a safety factor of great importance.

Series S23 Boosters are provided either with (Model S23R) or without (Model S23N) an integral relief valve. Model S23N is used with Vickers VT16 and VT17 pumps that have integral volume control and relief valve. When the larger volume Series V200 pump is used and a volume control is required in the circuit, the S23N is used with a separate combination valve (see Series FM2 below). Model S23R is used with the Series V200 pumps that have no integral valving, for applications where a volume control is not required.

MORE VERSATILE INSTALLATION

In Series S23 Boosters, the servo ball stud housing is symmetrical, and can be assembled in any one of four positions. This and the compactness of the Booster makes application easier . . . increases the number of applications which can be made without major engineering changes. Series S23 Boosters can be mounted interchangeably with Models S6-277 and S6-279 Boosters.

REQUIRES LESS SPACE

The new booster has been reduced in size by the redesign of the servo control valve. The tube connecting the servo valve to the rod end has been relocated and is now on the same side as the fitting connection. As a result of these changes, Series S23 requires less space . . . works in closer quarters.

ASK FOR NEW BULLETIN M5106

7062

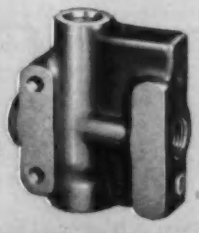
VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1454 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: • ATLANTA • CHICAGO AREA (Brookfield) • CINCINNATI • CLEVELAND • DETROIT HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS NEW YORK AREA (Summit, N. J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • ROCHESTER ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE ST. LOUIS • TULSA • WASHINGTON • WORCESTER

VICKERS® VOLUME CONTROL and OVERLOAD RELIEF VALVE

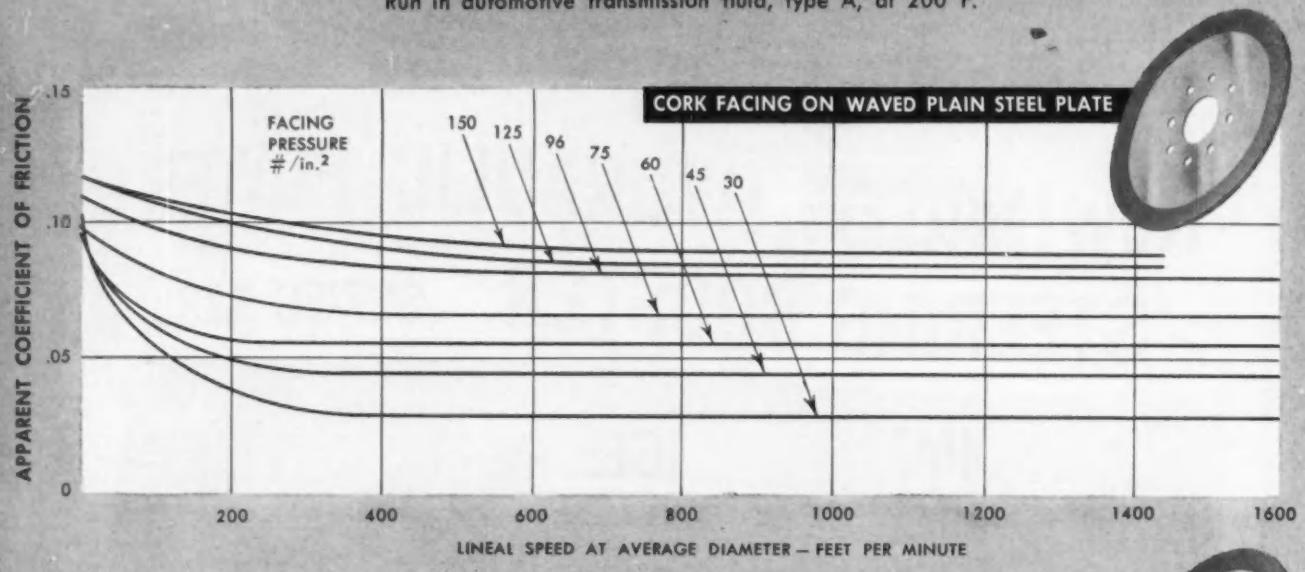


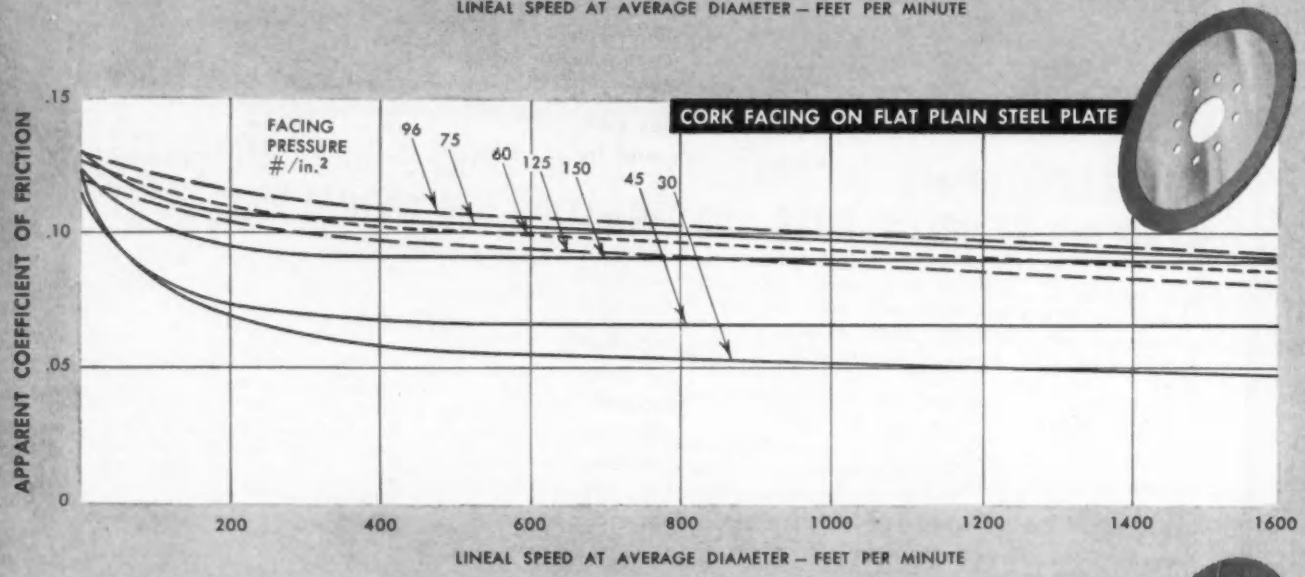
Five sizes of Series FM2 Valves were developed primarily for hydraulic power steering on trucks, buses and materials handling equipment where the pump does not include a volume control valve. The FM2 improves steering booster performance by providing a relatively constant volume of oil regardless of engine speed variations. An integral relief valve is included.

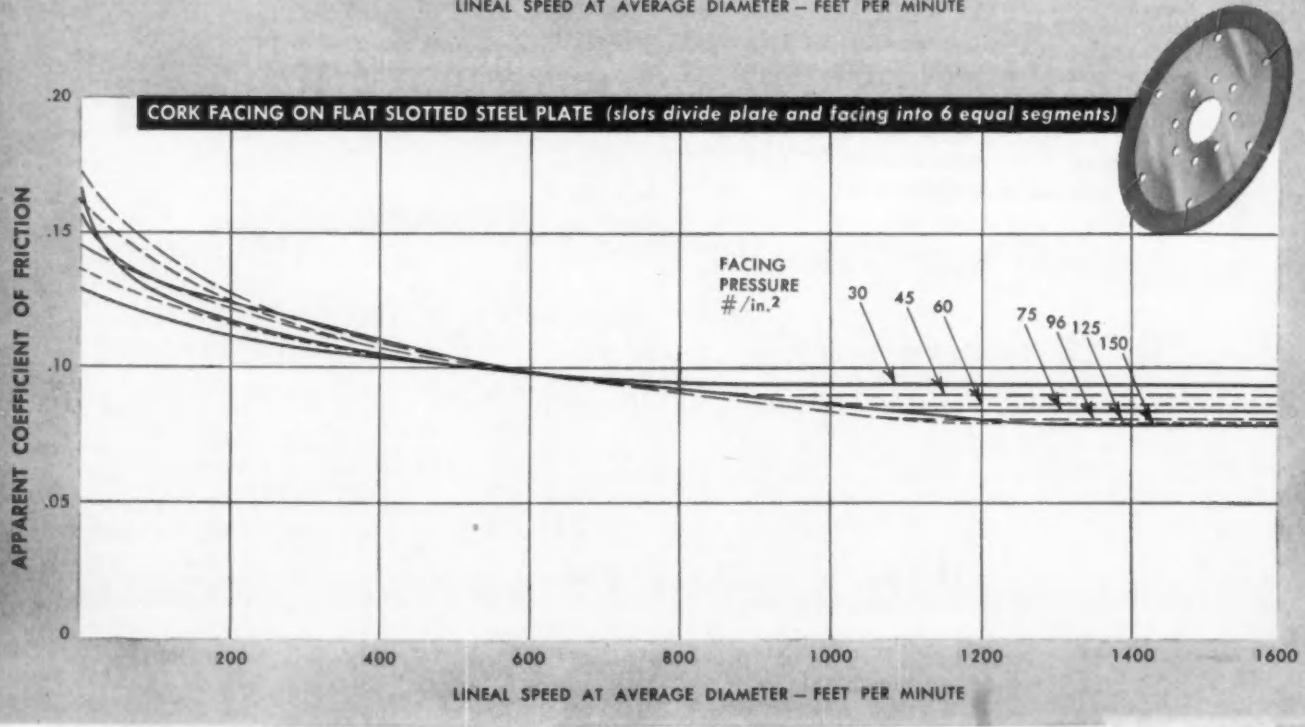
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

The Effect of Change in Plate Design

All test plates 6¼" I.D. x 7½" O.D. Same friction material on each plate.
Run in automotive transmission fluid, type A, at 200°F.







CORK CLUTCH FACINGS:

HOW ENGAGEMENT CHARACTERISTICS CAN BE MODIFIED BY SIMPLE CHANGES IN PLATE DESIGN

One of the unique advantages of cork-compound friction materials in wet clutches is that relatively simple changes in plate design allow the designer to control and manipulate the oil film and thus produce the desired engagement characteristics.

This versatility of cork facings stems from their unusually high coefficient of friction when immersed in oil, and from their inherent flexibility which permits the use of waved or coned plates.

The curves shown at the left show how typical changes in plate design may be used to modify wet clutch behavior. In each case, the plate size and friction material were identical. Yet the apparent coefficients of friction vary widely because of differences in plate design. For example:

On waved steel plates, (top chart) the cork facings apparently ride on the oil film at low pressures, like a Kingsbury Thrust Bearing. As pressure is increased, however, the waved plate flattens and better contact is made. When this happens, the apparent coefficient of friction rises until, at 150 psi., it equals the value at equivalent pressure shown for the other two plate designs.

On flat plain steel plates, (middle chart) the cork facings develop low friction values at low pressures. But full contact is generated much more quickly.

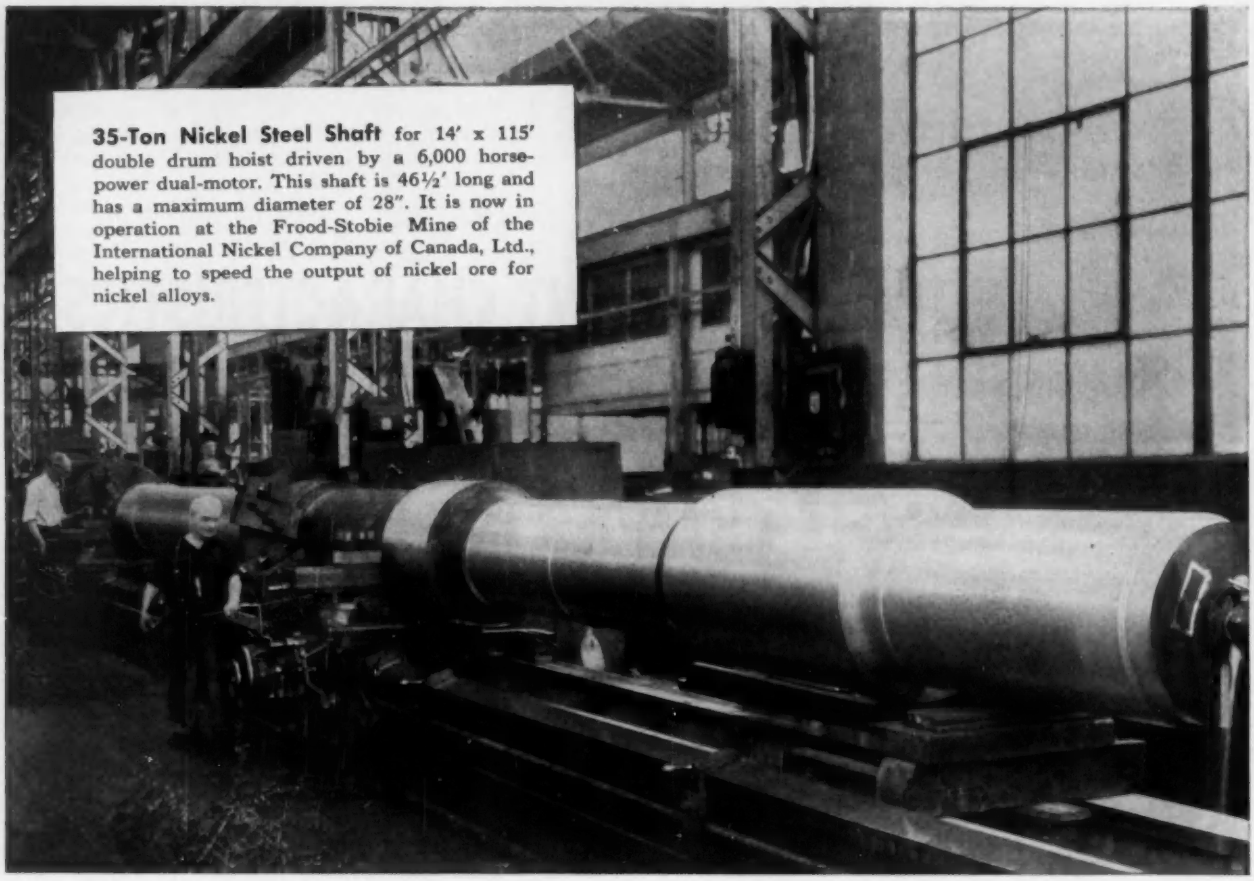
On flat slotted steel plates, (bottom chart) the cork facings produce apparent coefficients of friction that fall within a relatively narrow range. The slots apparently set up a "squeegee" action that tends to wipe away the separating oil film, even at low engagement pressures.

Controlling oil film controls engagement. In each of the examples given here, it is obvious that the oil film has a marked effect on the apparent coefficients of friction developed at pressures below those required to bring the facing into full contact with the opposing plate. However, as the charts demonstrate, simple changes in plate design enable the designer to control the oil film and thus produce the characteristics desired.

For more information on the design versatility of cork-compound friction materials, send for your free copy of our new 1955 booklet, "Armstrong Resilient Friction Materials." Write on your letterhead to Armstrong Cork Company, Industrial Division, 7202 Irvin Street, Lancaster, Penna.

Armstrong FRICTION MATERIALS

. . used wherever performance counts



35-Ton Nickel Steel Shaft for 14' x 115' double drum hoist driven by a 6,000 horsepower dual-motor. This shaft is 46½' long and has a maximum diameter of 28". It is now in operation at the Frood-Stobie Mine of the International Nickel Company of Canada, Ltd., helping to speed the output of nickel ore for nickel alloys.

How nickel strengthened the shaft for Canada's highest powered mine hoist

IN LARGE FORGINGS such as this giant shaft, high tensile and elastic properties do not come easily.

Liquid quenching of heavy forgings is usually impractical. Even when the shape is such that this treatment may be safely applied, the section sizes involved often restrict cooling to rates which render the quench ineffective.

Increased strength, hardness, toughness and other mechanical properties in a large forging depend to a great extent upon selection of alloy content.

Accordingly, to attain maximum strength and toughness in the shaft of Canada's highest powered mine hoist, at our own Frood-Stobie mine, we specified a shaft forged of 3½% nickel steel . . .

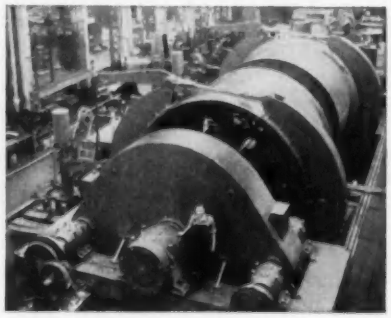
Because nickel, either alone or in combination with other alloying elements, provides a number of advantages.

For one thing, it has a strengthening effect on ferrite . . . independent of carbon content or heat treatment of the steel.

For another, it lowers the rate and temperature of the upper transformation, thus inducing better response to the necessarily milder heat treatments used. And it reduces grain growth.

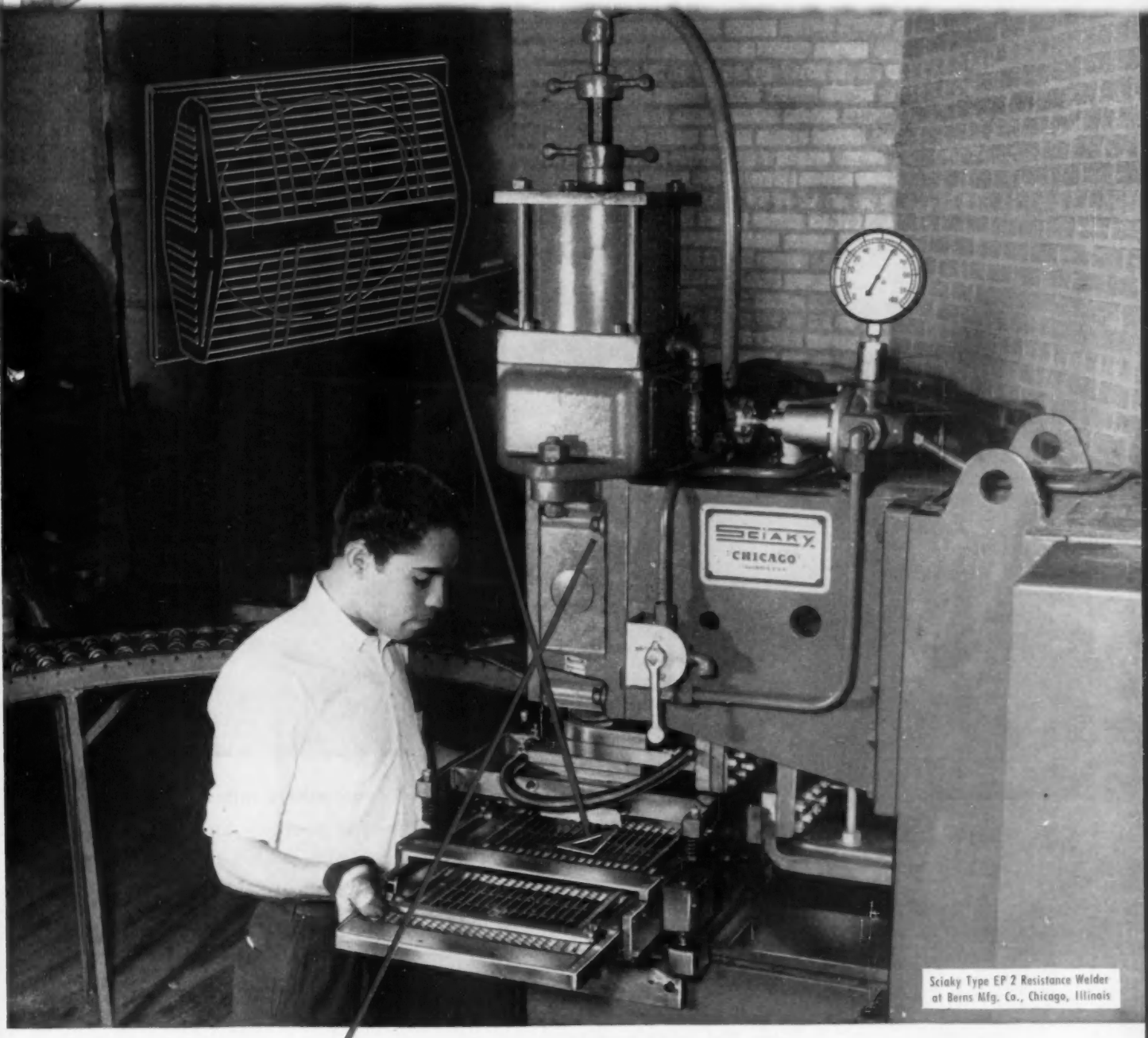
Whenever you face a metal problem, let us help you make a selection that will meet your particular fabricating and service requirements. Send us details of your applications, for our suggestions.

INCO TRADE MARK



Double Drum Hoist for the Frood-Stobie Mine, during course of shop erection by the builder, The John Bertram & Sons Co., Ltd., Dundas, Ontario. Spiders that support the steel shell of the hoisting drum were cast in an iron containing 1½% nickel . . . to assure adequate strength in the 74,600-pound drum-spider assembly. This hoist, operated by push button control from a station far underground, can lift skips containing 15 tons of nickel-copper ore, at an average rate of 14,000 tons daily.

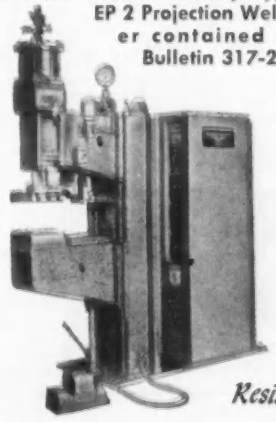
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.



Sciaky Type EP 2 Resistance Welder at Berns Mfg. Co., Chicago, Illinois

NEW SCIAKY DESIGN . . . COMPETITIVELY PRICED

Write for complete specifications showing minimum to maximum welding capacities for the standard Sciaky Type EP 2 Projection Welder contained in Bulletin 317-2.



PRODUCTION JUMPS 420% . . .

One Standard Sciaky Welder Does the Work of Four!

With one welder Berns was producing only one-quarter the needed production of 29 piece, 10 gauge wire grills for their nationally known Air King Fan. Instead of selling three more machines, Sciaky provided the newly designed, standard EP 2 Welder equipped with simple tooling to replace the original machine. Production jumped 420% as one machine does the work of four plus, the customer has the original welder for other work.

Write for the complete details of Berns' impressive production increase and equipment savings as well as other similar examples of single welder applications contained in "Resistance Welding at Work", Vol. 4, No. 1.

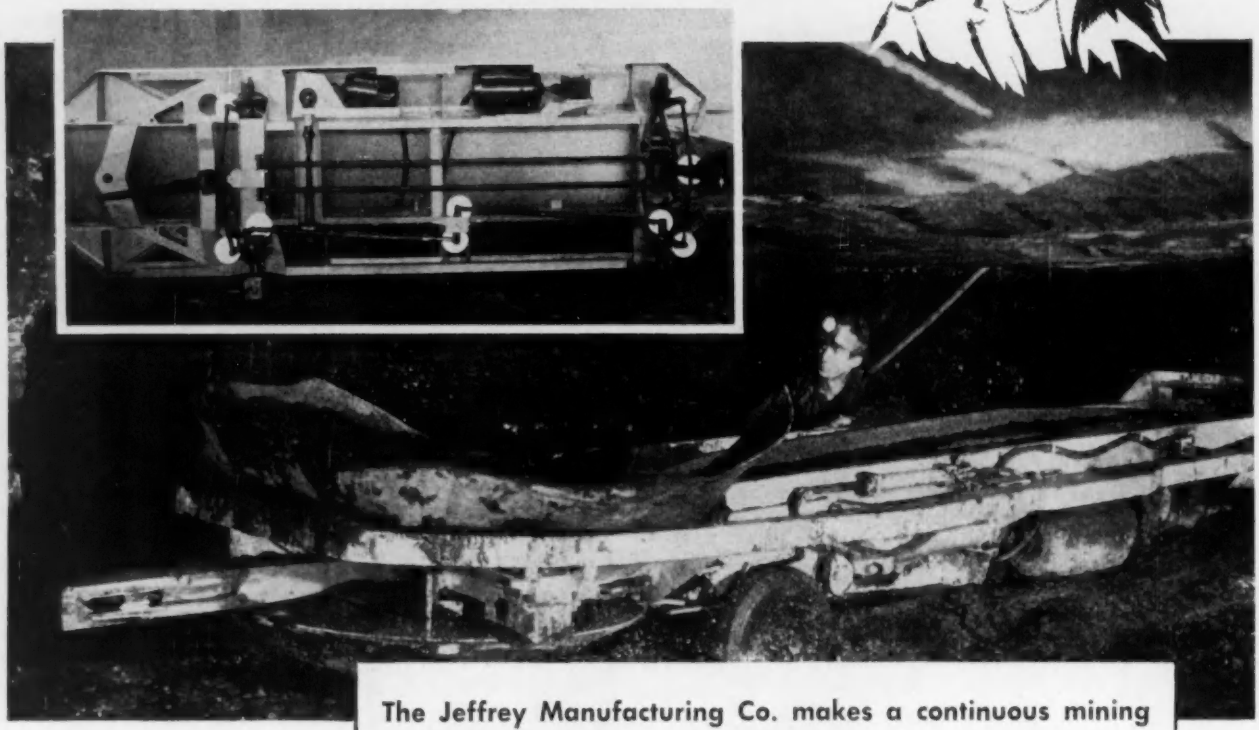
These typical advantages of Sciaky resistance welding may well be applied to your fabricating operations. Welders designed to do *more useful work* at *lower operating cost* with *maximum reliability* is basic to Sciaky design.

Largest Manufacturers of Electric Resistance Welding Machines in the World

SCIAKY

Sciaky Bros., Inc., 4913 West 67th Street, Chicago 38, Illinois

pointing the way to . . .
GREATER ECONOMY and EFFICIENCY



The Jeffrey Manufacturing Co. makes a continuous mining machine capable of mining 50 to 100 tons of coal per man day, and "Molveyor", a unique train of wheel mounted sectional belts of 15' lengths to convey this high production from the continuous mining machine to the main transportation system — a distance of up to 300 feet or more. A new and safer method of mining coal with greater economy and efficiency.

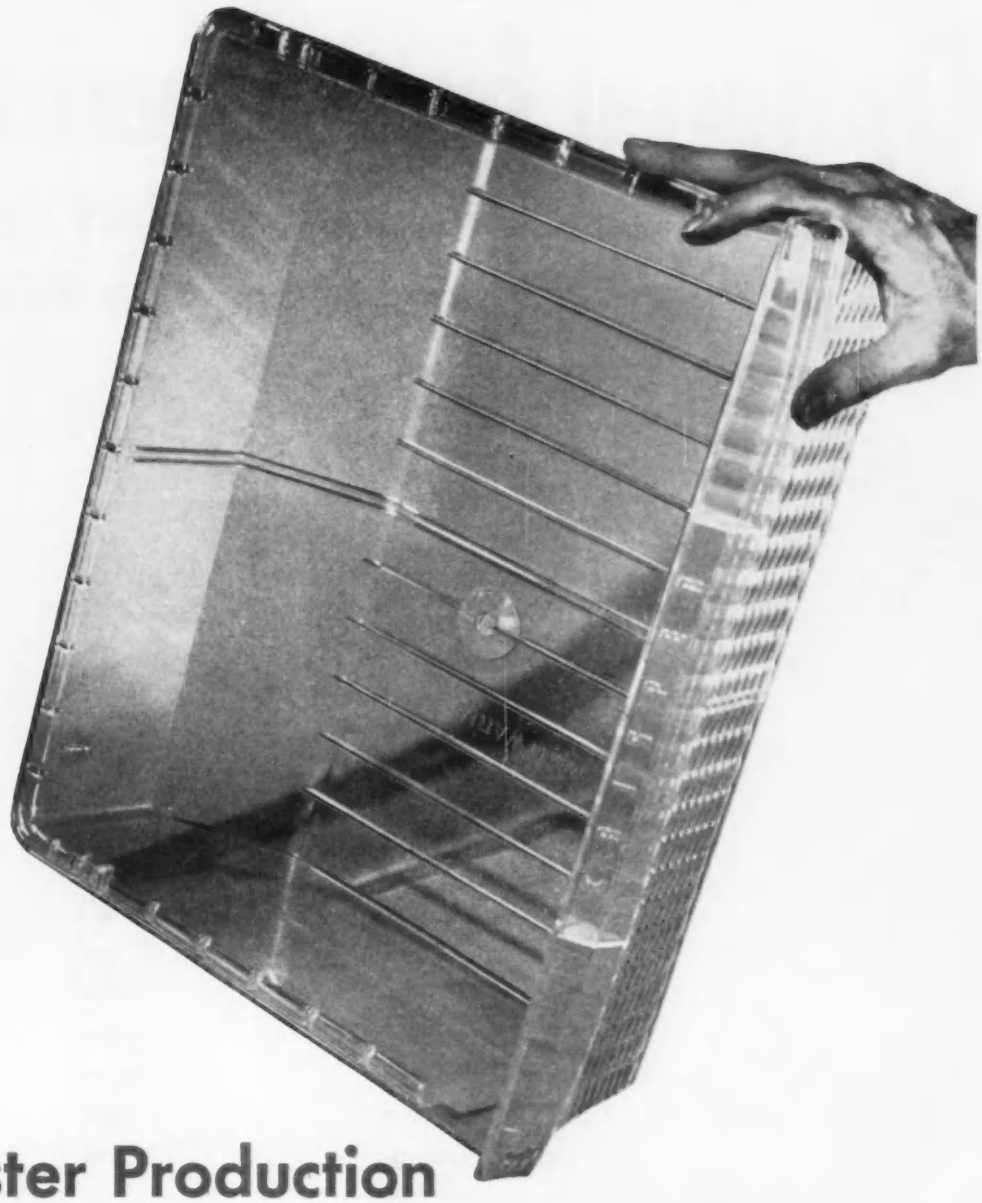
HEIM *Unibal* ROD ENDS are used in ten locations as circled in the shop picture of the frame of the Molveyor. Here is real punishment for every part on this hard working, heavy duty coal mining equipment. Heim Rod Ends were chosen because they deliver trouble-free performance under even adverse conditions — they correct misalignment in every direction — they are smooth in operation — and they stand up under the heavy loads they are called upon to carry.

You don't make coal mining equipment, you say.

But if, in the operation of *your* product, you must transmit motion or force at varying angles, *there* is the spot for a **HEIM** ***Unibal***. Our catalog has engineering data, specifications, and illustrations. You should have a copy in your files.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT



25% Faster Production for this big Styrene Plastic Molding

If you want cleanly-molded, glossy-surfaced, transparent styrene plastic moldings like this 36-ounce refrigerator crisper pan, you'll be interested in the new BAKELITE Styrene Molding material SMD-3500.

Plastics molders like this material's combination of high plasticity and fast set-up. It cut the molding cycle for this crisper pan 25 per cent. Production in specially-designed equipment and an advanced system of quality control ensure uniformity of color and molding properties of SMD-3500.

For parts requiring resistance to high heat distortion, a companion material, SMD-3000, provides the same ease of molding and other basic properties as SMD-3500. For assistance in applying these materials, write Dept. YR-10.

Refrigerator crisper pan molded by **General Electric Co.**, Decatur, Ill.

BAKELITE
TRADE-MARK
STYRENE PLASTICS

TRADE (B) MARK

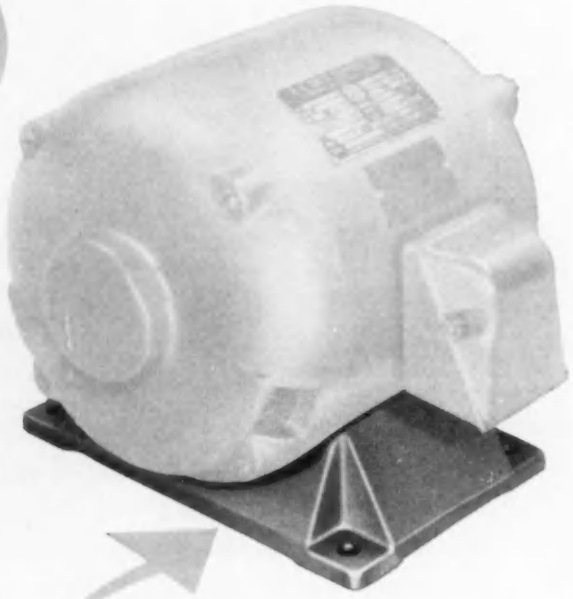
BAKELITE COMPANY *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

Optional frame mountings

mean you needn't change product design to enjoy all the advantages of the new NEMA ratings

1. Want to use new NEMA mounting dimensions for integral horsepower motors?

Do it with A. O. Smith Integrals! Optional frame mountings fit NEMA sizes 182, 184, 213, 215.



2. Want to keep your old mountings but still enjoy all the advantages of new NEMA ratings?

Do it with A. O. Smith integrals! Optional frame mountings fit old NEMA sizes 203, 204, 224, 225.

A. O. Smith understands your problems . . . understands the costs involved in adapting your manufacturing processes to suit the motor industry's new mounting dimensions for integral hp motors.

That's why we offer our motors with optional frame mountings — drilled to the old specifications or the new. You get all the performance — all the advantages — you'd want from an integral hp motor (1 — 150 hp) . . . plus easy adaptability.

Another reason why it pays to see A. O. Smith first for motors. Our specialty is custom-engineering to fit your particular needs. Write today for full details.

Through research A.O. Smith *. . . a better way*

A.O.Smith

CORPORATION

ELECTRIC MOTOR DIVISION

P. O. Box 170 • Dayton, Ohio

International Division: Milwaukee 1, Wisconsin

More than meets the eye

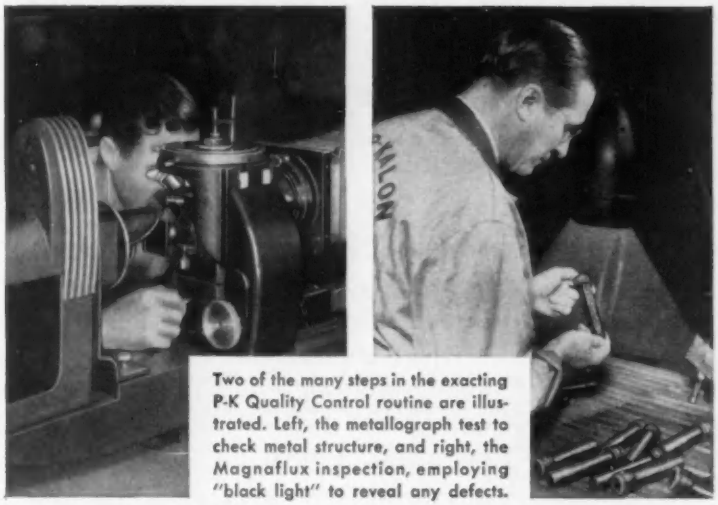
P-K Socket Screws, at a glance, may look substantially like those you buy from "habit." You have to "look *beyond* the hex" for the difference.

If you don't, you are buying with a "blind spot" that can block your way to *proved* benefits other buyers are using to advantage. Parker-Kalon's exacting Quality Control is only one of the advantages you don't see until you "look beyond the hex."

Look Beyond the Hex

Compare every detail of product and service. Compare for advanced design . . . for proved assembly strength . . . for buying aids, and supply service. Get all the facts, and try P-K Socket Screws. You'll find they take top rating in any test.

Get samples, information from your P-K Distributor, or write: Parker-Kalon Division, General American Transportation Corporation, 200 Varick Street, New York 14, N. Y.



Two of the many steps in the exacting P-K Quality Control routine are illustrated. Left, the metallograph test to check metal structure, and right, the Magnaflux inspection, employing "black light" to reveal any defects.

FOR TOP QUALITY and tolerance gaged to your most exacting specifications — and guaranteed.

FOR ADVANCED DESIGN that speeds assemblies — makes them simpler, stronger — and saves errors.

FOR ASSEMBLY STRENGTH okayed in a million punishing tests by thousands of satisfied users.

FOR PLANNING AIDS and buying data patterned to your special needs, plus advice on assembly.

FOR SUPPLY SERVICE set up for fast action and lower purchasing expense — by local Distributors.

FOR ANY STYLE OR SIZE You'll find any Socket Screw you need in P-K's complete line. Hex Keys in all sizes, and several handy sets.

PARKER-KALON SOCKET SCREWS

GET ALL THESE ESSENTIALS OF COST-WISE ASSEMBLY GET P-K

In Stock... see your nearby P-K Distributor . . . your local Supply and Service Specialist

UNHEARD-OF STRENGTH IN STEEL PARTS...

with a heat treatment developed by Cleveland Pneumatic

NOW YOU CAN DESIGN highly stressed steel parts that will weigh less than you ever thought possible...

At Cleveland Pneumatic, we have developed ways to give steel parts far greater strength and durability than have ever been considered possible... tensile strengths of 260,000 psi in alloys that only a few years ago were limited to 180,000 psi. Years of intensive research in our plant have developed the necessary precise controls... in designing, heat treating, machining and plating and in the important intermediate processing.

Right now, this combination of Cleveland Pneumatic's heat treatment and machining is doing almost unbelievable things for the strength-to-weight ratios of highly stressed steel parts in aircraft. Weights are being reduced without reducing strength... or strength can be increased without "beefing-up" the size and weight of parts.

Wouldn't you like to have your designers and engineers talk with us about using Cleveland Pneumatic high-heat-treat-and machining methods in *your* assemblies? Write to:

Cleveland Pneumatic
Tool Company CLEVELAND 5, OHIO
Department E-255

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Harper's engineers are specialists in cold heading and have had wide experience in the design and production of unusual specials from nonferrous, stainless steel and high temperature alloys.

Harper field engineers are available to work with you on any fastening problem. Call the nearest Harper office or write direct.

Harper is also the largest exclusive producer of bolts, nuts, screws, washers, rivets from corrosion-resistant metals. Branch offices and distributor's warehouses are located in every major market area.

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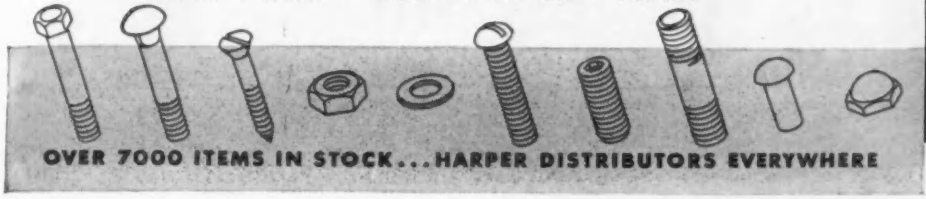
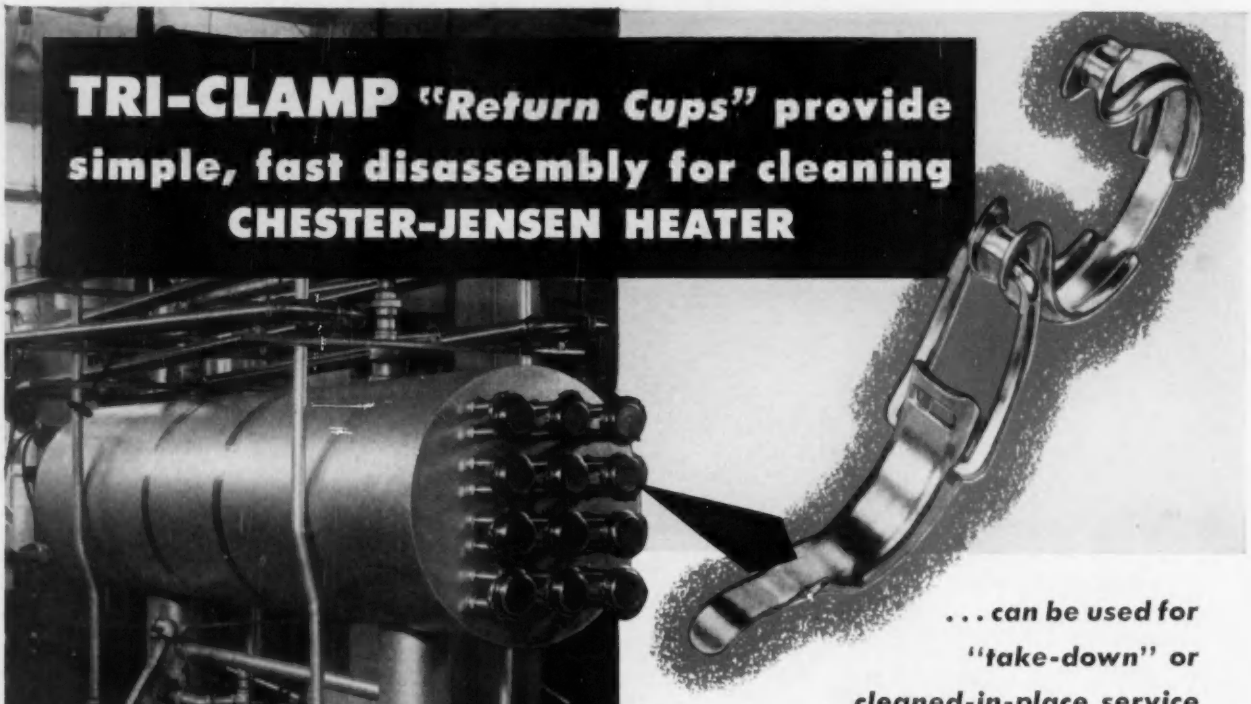
of Brass • Bronze • Monel • Aluminum • Stainless



OVER 7000 ITEMS IN STOCK... HARPER DISTRIBUTORS EVERYWHERE

HARPER
EVERLASTING FASTENINGS

TRI-CLAMP "Return Cups" provide simple, fast disassembly for cleaning CHESTER-JENSEN HEATER

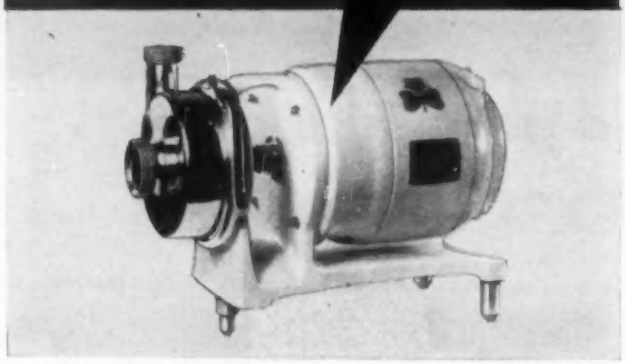


. . . can be used for "take-down" or cleaned-in-place service

• This Chester-Jensen Heater is unique in that it does not employ conventional methods of return flow. Instead, a stainless steel return cup takes the place of complex return covers or fitting assemblies. The return cup is held in place with a simple TRI-CLAMP toggle union.

The advantages of these Tri-Clover snap-action clamps are obvious—faster, simpler original assembly at lower cost—and speedy disassembly for cleaning, inspection, or replacement.

While this is a specialized application of the exclusive Tri-Clover TRI-CLAMP principle, the same basic advantages apply to the full line of TRI-CLAMP stainless steel ells, crosses, tees, laterals, etc., for use in either "take-down" or cleaned-in-place lines. When installed in "take-down" lines, the "easy on and off" feature means a tremendous savings in labor at wash-up time. When used in C-I-P lines, Tri-Clamp fittings offer important savings in both original cost and in maintenance expense.



Included on the Chester-Jensen heater system is the Tri-Clover *"Pump King,"* one of a complete line of Tri-Clover sanitary pumps — that years of service have proven will out-perform and out-last any other centrifugal pumps available to the dairy industry. These pumps feature: *Wide choice of seals — Design that actually exceeds 3A sanitary standards — Streamline heads for faster assembly and disassembly — Patented impeller for higher efficiency — Pump heads that can be turned 360 degrees to simplify installation* — and many other features which make it the most "copied" pump in the industry. *For full details, send for Pump Catalog 253.*

SEND FOR NEW CATALOG

Complete details and specifications covering the full line of TRI-CLAMP Stainless Steel Fittings are available in the new Tri-Clover Catalog 1-154. Send for your copy today.

S155

LADISH CO.
Tri-Clover DIVISION
KENOSHA WISCONSIN

See your nearest TRI-CLOVER DISTRIBUTOR
EXPORT DEPT., 8 So. Michigan, CHICAGO 3, U.S.A. Cable: TRICLO, CHICAGO

Here are 6 reasons why Ohio Knife Hardened Bedways are best for you

1. You buy consistent quality at a fixed cost, thus eliminating the uncertainties of producing bedways yourself. When you buy from Ohio Knife you can depend on bedway accuracy, prompt delivery and exact costs.

2. OK ways are so hard they're practically wear-proof, which helps maintain constant accuracy throughout the life of the machine. This extreme hardness, 65-66 Rockwell "C", is uniform to 3/16" depth. The Gisholt Machine Co. demonstrated OK bedway hardness by taking a section from the way, making it into a tool bit, and cutting 1045 cold-rolled steel with it.

3. Because of the OK process of welding hardened tool steel to a soft steel backing (under 2500 tons pressure) we can produce extra long lengths that will not warp or bow even if you store them for long periods before installation. Thus, your high assembly costs of butting short pieces is eliminated.

4. A complete selection of bedway shapes, sizes and lengths is available to you. OK ways can be built to your specifications for any application.

5. Ohio Knife hardened bedways are so well known for their high quality that many machine buyers look for and favor machine tools built with OK ways. So to gain a big sales point, make sure you use OK bedways.

6. OK ways are also available in welded aluminum bronze.

Write to Dept. 32-B for comprehensive bulletin.

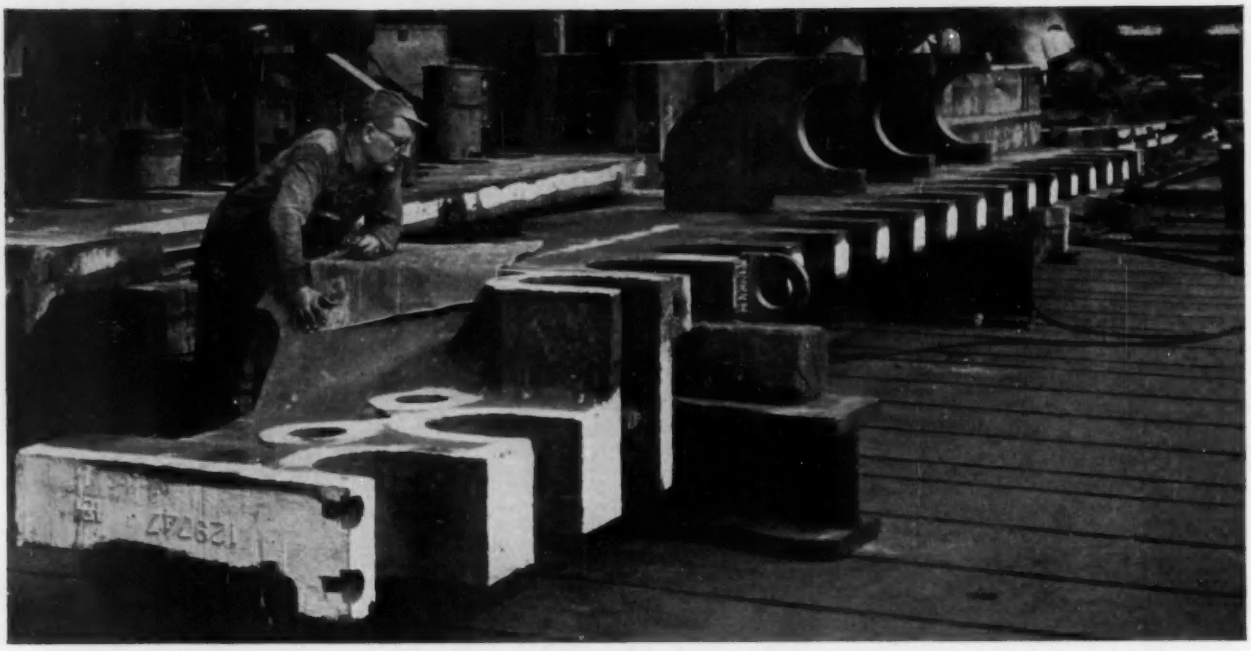
Manufacturers for the Metal Working Industry of:

SLITTER KNIVES · SHEAR BLADES · ROTARY SHEAR KNIVES · HARDENED SPACERS · HARDENED WAYS · GIBS · BALL RACES · BRONZE WAYS · WEAR STRIPS

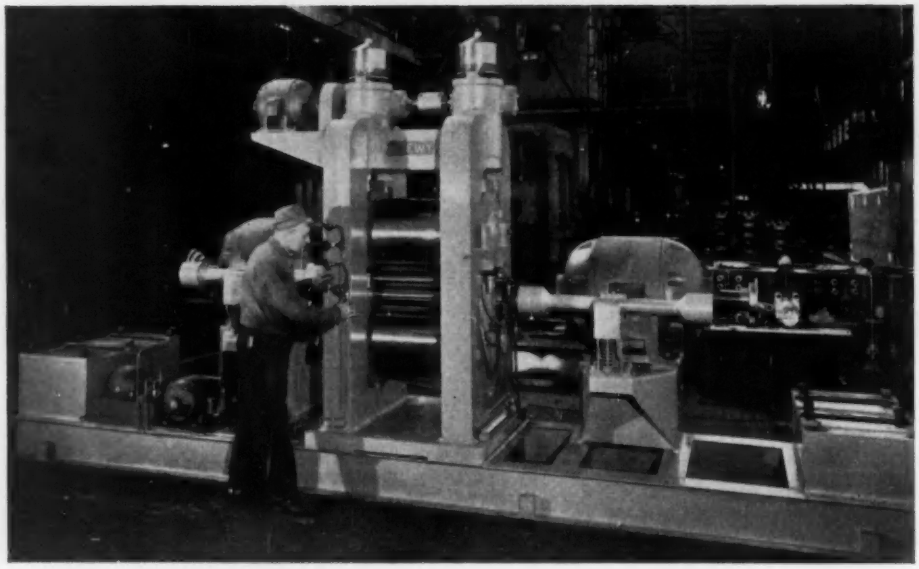
THE OHIO KNIFE CO.

CINCINNATI 23, OHIO

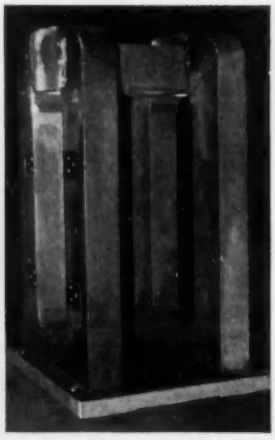
What's New In Weldments



FORGED, CAST AND ROLLED-STEEL TABLE GIRDER—Here's the sort of composite weldment you don't see every day. Over 33 ft long and tipping the scales at 26 tons over-all, it is an important part of the new 160-in. plate mill tilting table at our Sparrows Point, Md., Plant. Securely welded to a 7-in.-thick rolled plate weighing 18 tons are a 7100-lb steel casting (foreground), an 8600-lb forging (far end), and 3 flame-cut brackets. Its companion piece is behind the workman.



MILL FOR RESEARCH WORK—Shown here shop-assembled without gear-reducers is a unique 4-high laboratory mill with 3½-in. by 18-in. by 20-in. face rolls. It was designed and engineered by the Loewy Rolling Mill Division, Hydropress, Inc., for critical research work. The mill has unusually small but powerful work rolls which are capable of reducing extremely hard material to thin gauges. Each of these work rolls has an individual motor drive and an electric screwdown.



RUGGED HOUSING—Backbone of the mill shown at the left is this 5-ton housing, hand-welded and stress-relieved in our Weldment Shop. The rolled steel plates are of ASTM grades A283 and A284, the heavy columns being 7 in. thick.

For further information about Bethlehem Weldments, call on the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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A new chemical rubber from Du Pont

HYPALON®

(Chlorosulfonated Polyethylene)

Here's a new construction material for you . . . a new elastomer with a number of unusual properties important in industrial design.

Du Pont "Hypalon" brings exceptional stability to rubber products, resulting in improved resistance to deterioration. Products of "Hypalon" can outlast ordinary resilient products under such demanding service conditions as highly corrosive atmospheres, unlimited ozone concentrations, or prolonged exposure to high temperatures. They can be compounded over a range of light-stable colors at no sacrifice to their basic properties.

Almost all manufacturers who make rubber products can produce products of "Hypalon." Possible uses for Du Pont "Hypalon" include protective coatings for rubber, wood and metal; gaskets and packings, tank linings, coated fabrics, and a wide variety of molded and extruded goods. Be sure you get all the facts about this promising new Du Pont elastomer. Just clip and mail coupon below.

Properly compounded, "Hypalon" has superior resistance to:

Ozone and oxygen—
Compounds of "Hypalon" are unaffected by ozone.

Heat and flame—
"Hypalon" has excellent resistance to heat, does not support combustion.

Weathering and flexing—
Vulcanizates have excellent resistance to exposure, flex-cracking.

Chemicals, grease and oil—
Exceptional resistance to deterioration, even from oxidizing acids and chemicals.

MAIL THIS COUPON FOR FREE FOLDER

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Please send me your folder on the properties and uses of "Hypalon."

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HYPALON®
(Chlorosulfonated Polyethylene)

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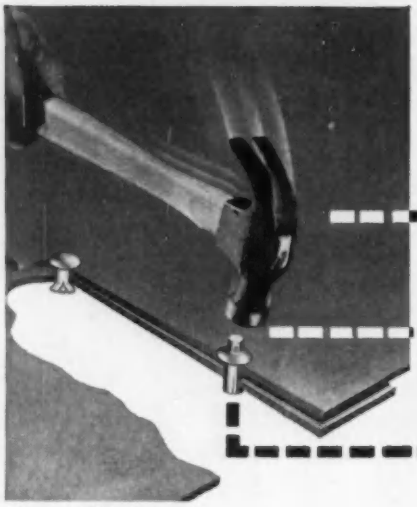
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

only SOUTHCO drive rivets offer all these benefits!



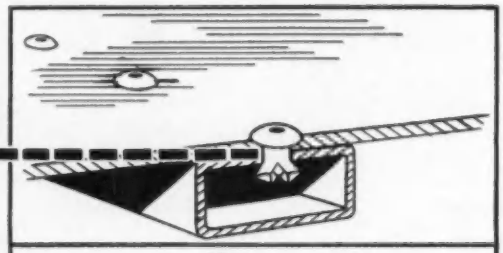
A HAMMER IS THE ONLY TOOL

DRIVE LIKE NAILS

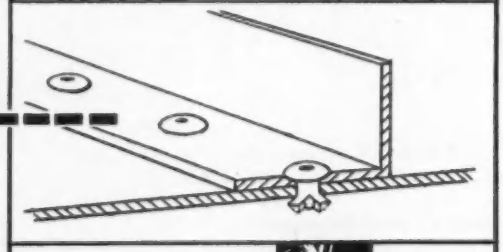
AUTOMATIC "PULL-UP" ACTION FORCES PARTS TOGETHER

Rivet and Mfg. Patented.

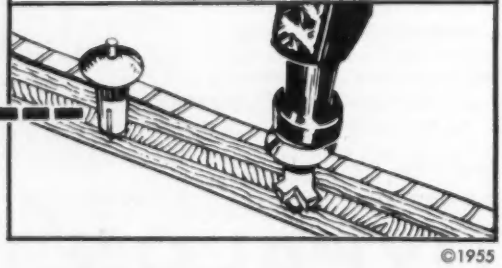
FOR BLIND APPLICATIONS



FOR ACCESS APPLICATIONS



FOR METAL-TO-WOOD APPLICATIONS



Note

No special tools to buy or maintain, no bucking up, no finishing, no noise, no material waste.

Just hit the pin, the rivet's in . . . that's all.

On your production line, where can savings be made with Southco Drive Rivets? Write for complete data. Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

SPEED ASSEMBLY . . . CUT COSTS

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PAWL • SCREW AND SPRING • DRIVE RIVETS • ANCHOR NUTS • ENGINEERED SPECIALTIES

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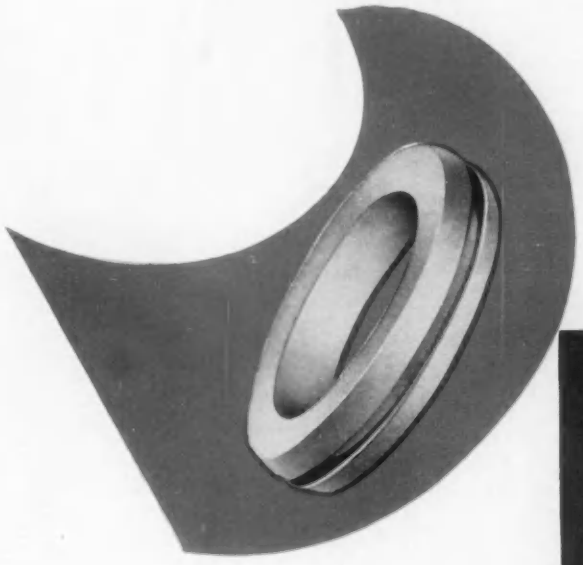
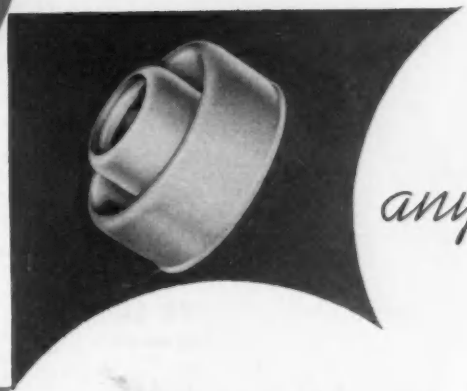
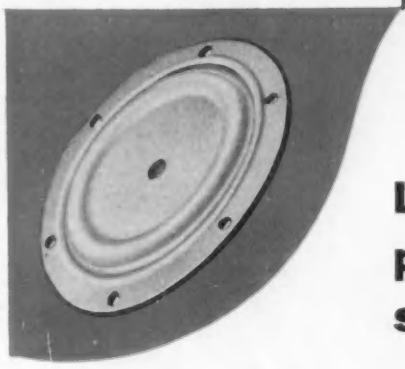
WHEREVER TWO OR MORE PARTS ARE FASTENED TOGETHER, STANDARD AND SPECIAL DESIGNS FOR IMPROVED PERFORMANCE AND LOWER PRODUCTION COSTS



any size...



any shape...



any application...

Linear precision molded silicones

Whenever your design specifies a synthetic molded rubber product to precise dimensions, *look to* LINEAR. Must it be water repellent, resistant to oxidation, or impervious to oils, acids or synthetic fluids? *Look to* LINEAR. Want a range of thermal stability from —125° F. to 500° F.—or better? *Look to* LINEAR!

The combination of micrometer accuracy and superior physicals in LINEAR Precision Molded Silicones results from constant research and testing. It extends into virtually every field of industry. Where dimensional stability or long shelf life is a must, it pays to specify LINEAR.

Whether you need Molded Diaphragms, Roto-Molded "O" Rings, Boots, Impeller Seals or a variety of odd-shaped components, including bonded-to-metal parts, LINEAR engineers can save you time and money. Let us discuss your needs in the design stage.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

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in your area is ready
to serve you . . . today!

THE BOSTON MAN'S BUSINESS: rubber products engineered to your job

Fast-Moving Boston Research

Gives You

Better Rubber Components!

The Boston Man has solved many problems almost identical with one that may be costing you money. If you require mechanical rubber components—from V-belts to mighty river-spanning conveyor belts, slender tubing to sturdy transmission belts—it will pay to do business with Boston's specialists. Behind every Boston product stands research unsurpassed in the industry. Boston's scientists, engineers and designers stand ready to meet your most exacting requirements. Contact your nearest distributor or Boston District Office:

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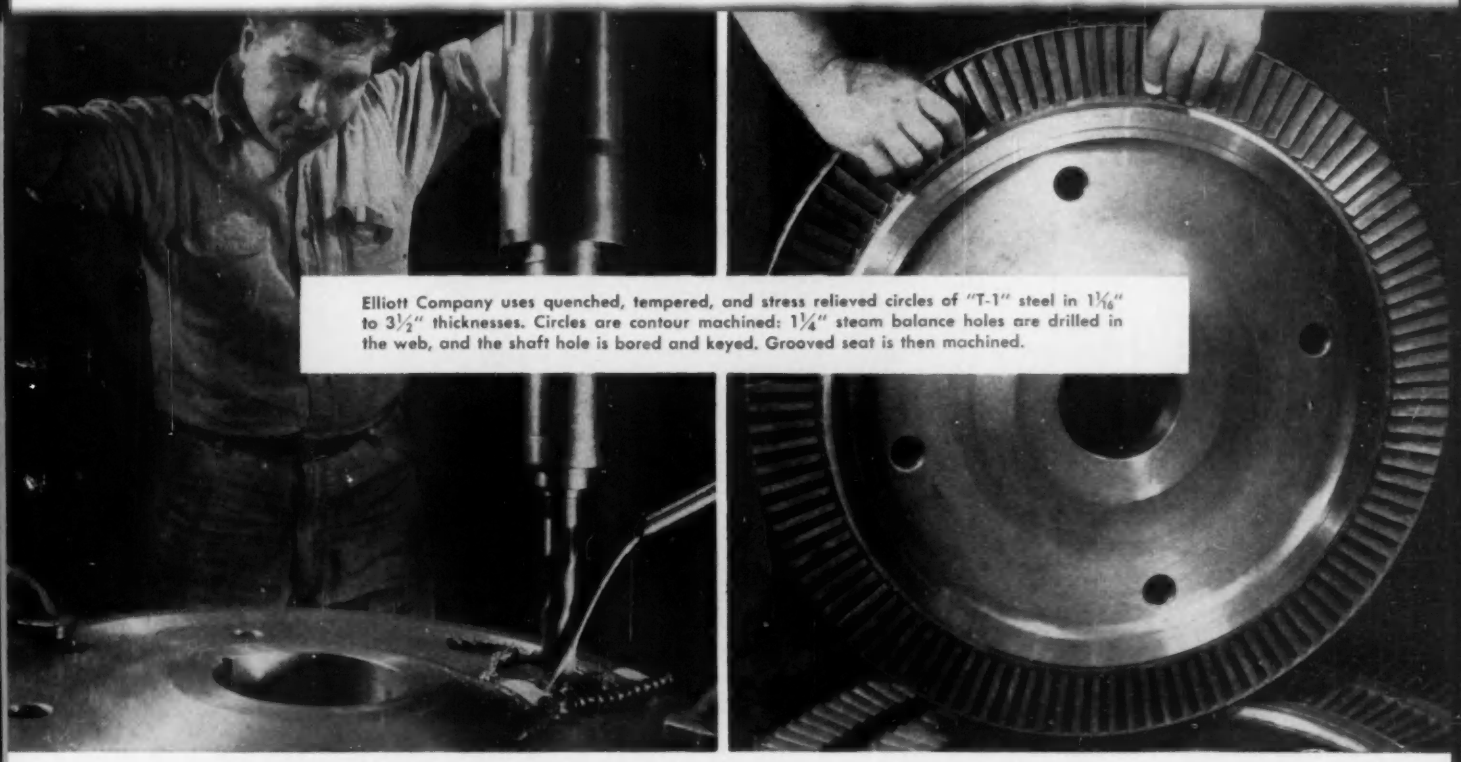

Elliott Company uses quenched, tempered, and stress relieved circles of "T-1" steel in 1 1/16" to 3 1/2" thicknesses. Circles are contour machined: 1 1/4" steam balance holes are drilled in the web, and the shaft hole is bored and keyed. Grooved seat is then machined.

New USS "T-1" Steel cuts material cost 60% in rotor discs of small turbines

Provides high strength at high temperature, and stability at high speed of rotation

• The Elliott Company, Jeannette, Pennsylvania, makes industrial steam turbines for driving pumps, fans, blowers, and other rotating equipment. The steel for the turbine discs must withstand high stresses at high temperatures and at speeds as high as 6,000 rpm. It must be sound throughout. That's why Elliott Company has switched to new USS "T-1" Steel in these discs.

"T-1" provides a minimum yield strength of 90,000 psi. and good creep rupture strength to 900°F. It poses no severe fabrication problems. What's more, "T-1" costs 60% less in this turbine application than the alloy steel previously used. And the switch to "T-1" required no change in design.

Although USS "T-1" Steel is comparatively new, it already has proved well suited to a great variety of applications. In addition to great high-temperature strength, it has extraordinary toughness at temperatures far below zero. It has excellent resistance to impact abuse, impact abrasion, and atmospheric corrosion. By taking advantage of these superior properties, you can reduce the size and weight, increase the strength and durability, and reduce the cost of such varied equipment as pressure vessels, power shovels, draft lines, storage tanks, conveyors, bridges, and towers. Where field fabrication or repairs are necessary or desirable, "T-1" cuts costs still further because it can be welded or flame cut either in shop or field without pre-heating or stress relieving.

Send the coupon for complete information.

United States Steel, Room 4639
525 William Penn Place
Pittsburgh 30, Pa.

☐ Please send me your booklet, "United States Steel presents T-1" which contains the full story of "T-1" steel.

☐ Have your representative get in touch with me.

Name.....

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USS "T-1" CONSTRUCTIONAL ALLOY STEEL

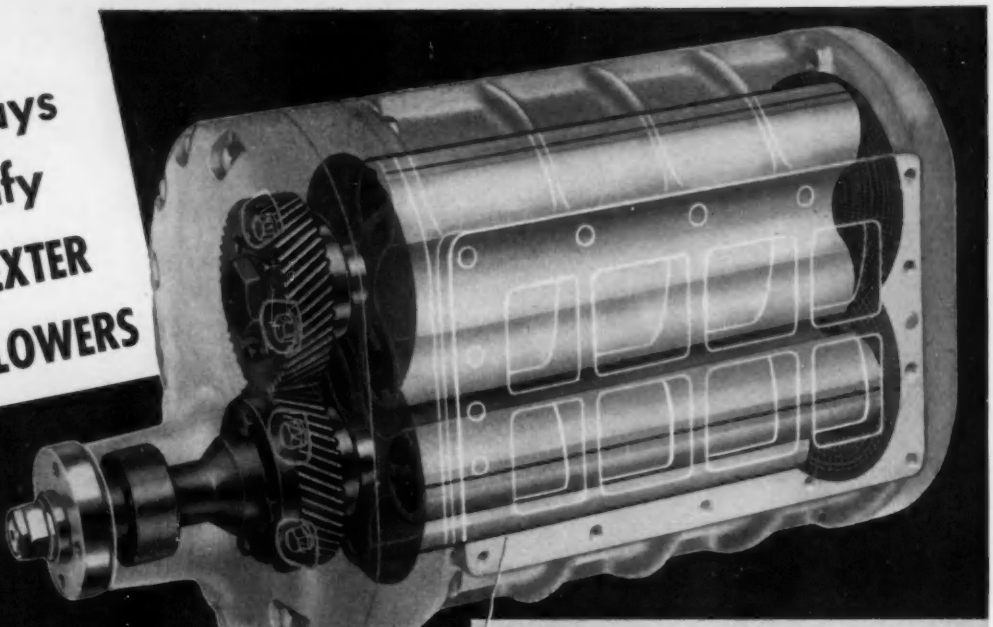
USS

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

5-271

UNITED STATES STEEL

why it pays to specify MIEHLE-DEXTER ROTARY BLOWERS



Greer Hydraulics did... and took guesswork out of aircraft testing operations

When Greer Hydraulics, Inc., called in Miehle-Dexter for Blowers on their aircraft cabin leakage test stands, the prime requisite was a lightweight, positive pressure blower to fit in limited space.

But Greer quickly learned how special Miehle-Dexter features increase service life and provide efficient performance. For instance, patented rubber-grid seals vulcanized to end plates eliminate metal-to-metal contact. And efficiency is increased by special wear strips locked into the tips of the rotor lobes. These are the key features that practically eliminate service worry . . . provide savings in operating and maintenance costs.

If you have a product or process requiring dependable movement of air or gas, it pays to call in Miehle-Dexter. Our engineers will gladly work with you, demonstrate how Miehle-Dexter positive displacement blowers can simplify operation and reduce costs for you. *Capacities available:* 50-4000 c.f.m. *Discharge pressure:* to 14 psig. *Vacuum:* to 15″ h.g. For more complete information, check and mail the coupon for new catalog No. 255.

Greer aircraft cabin leakage test stands use Miehle-Dexter Positive Displacement Blowers for pressure testing cockpit and fuselage. Single blower integrated into original design provides 400 c.f.m. at 10 psig.

send for new catalog

MIEHLE-DEXTER

md ROTARY BLOWERS

MIEHLE-DEXTER SUPERCHARGER
Division of Dexter Folder Company
103 Fourth Street, Racine, Wisconsin

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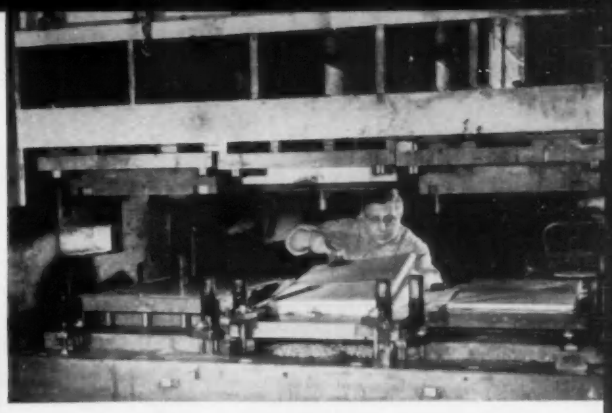

Hydraulic press where door panels are formed. Left-hand die punches and forms; center die second-forms and trims excess metal, right-hand die final forms.

Punching and counter-sinking holes for handle and fastenings.

Strikingly beautiful **color-chrome gas range** by Magic Chef, Inc., St. Louis, Mo.

How Stainless Steel helps Magic Chef bring glamour into the kitchen

MAGIC CHEF'S new *color-chrome gas range* is an eye-catcher anywhere you see it—in the kitchen or on the sales floor. Highlighting the beautiful decorator colors of the porcelain enamel top and sides is a front of gleaming Stainless Steel.

There's real beauty here, but that's not the whole story. There's the durability of long-lasting Stainless Steel. And there's the ease with which Stainless Steel's smooth, dense surface can be cleaned—year after year.

This is the kind of sales appeal that Stainless lends to an almost countless list of products. And you can have it with surprising ease of fabrication (See "Fabricating Facts"). Put this appeal in your products, and when you do, follow the lead of successful fabricators who use service-tested USS Stainless Steel in the products they make.

FABRICATING FACTS

Compartment door, oven door and broiler drawer panels are fabricated from USS 18-8 Stainless Steel sheets, No. 3 finish.

Sheets are dry-coated with drawing compound, then sheared to blank size. Forming takes place in an hydraulic press, using three dies. Stainless Steel sheets form easily and without distortion in a die setup designed for carbon steel sheets.

Panels are paper-wrapped to protect against scratching; holes for fasteners are punched and counter-sunk. Dry-coating is removed; panels are sub-assembled and sent to the production line for final assembly.

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

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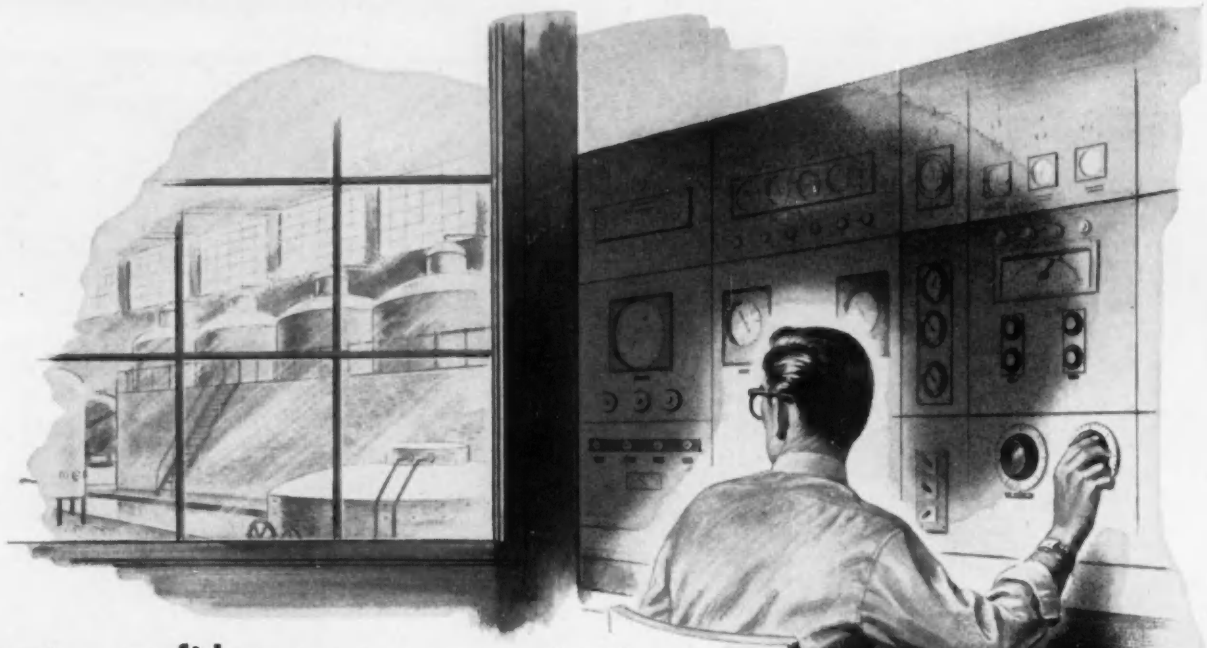
USS

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

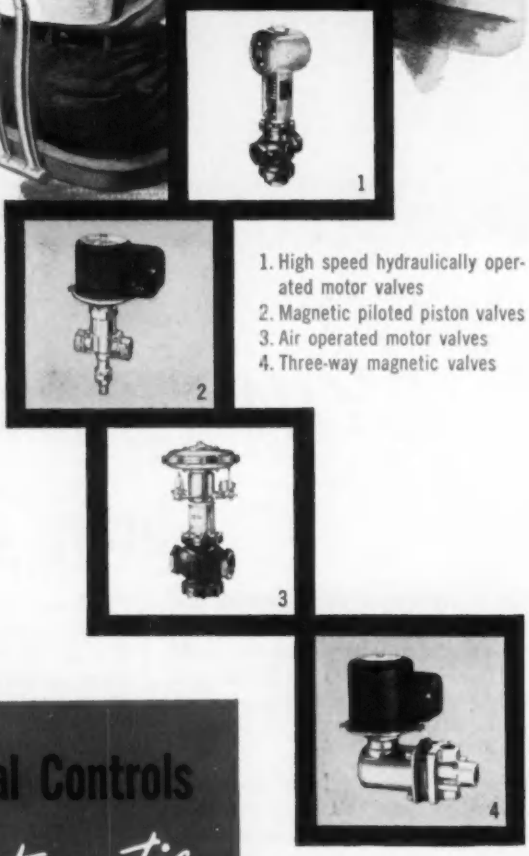
5-99

UNITED STATES STEEL



Here's a confidence man you can trust...

His confidence is in control—the complex, automatically timed control of program and sequence. It makes him complete master of the vast processing operation underway before him. He knows the engineered performance is taking place as scheduled—unmarred by human fallacy or fatigue . . . unaffected by judgments less than perfect, by skills unlearned, by fallible hands, by lapses of attention. He knows that flow and level are on the mark, pressure perfect, temperature pin-pointed, timing true to the split-second operation—all automatically. And the famous red shield of General Controls on the automatic devices which make this miracle of technology possible is his assurance that everything is under control—always, in all ways. He is confident—and you can trust his confidence!



1. High speed hydraulically operated motor valves
2. Magnetic piloted piston valves
3. Air operated motor valves
4. Three-way magnetic valves

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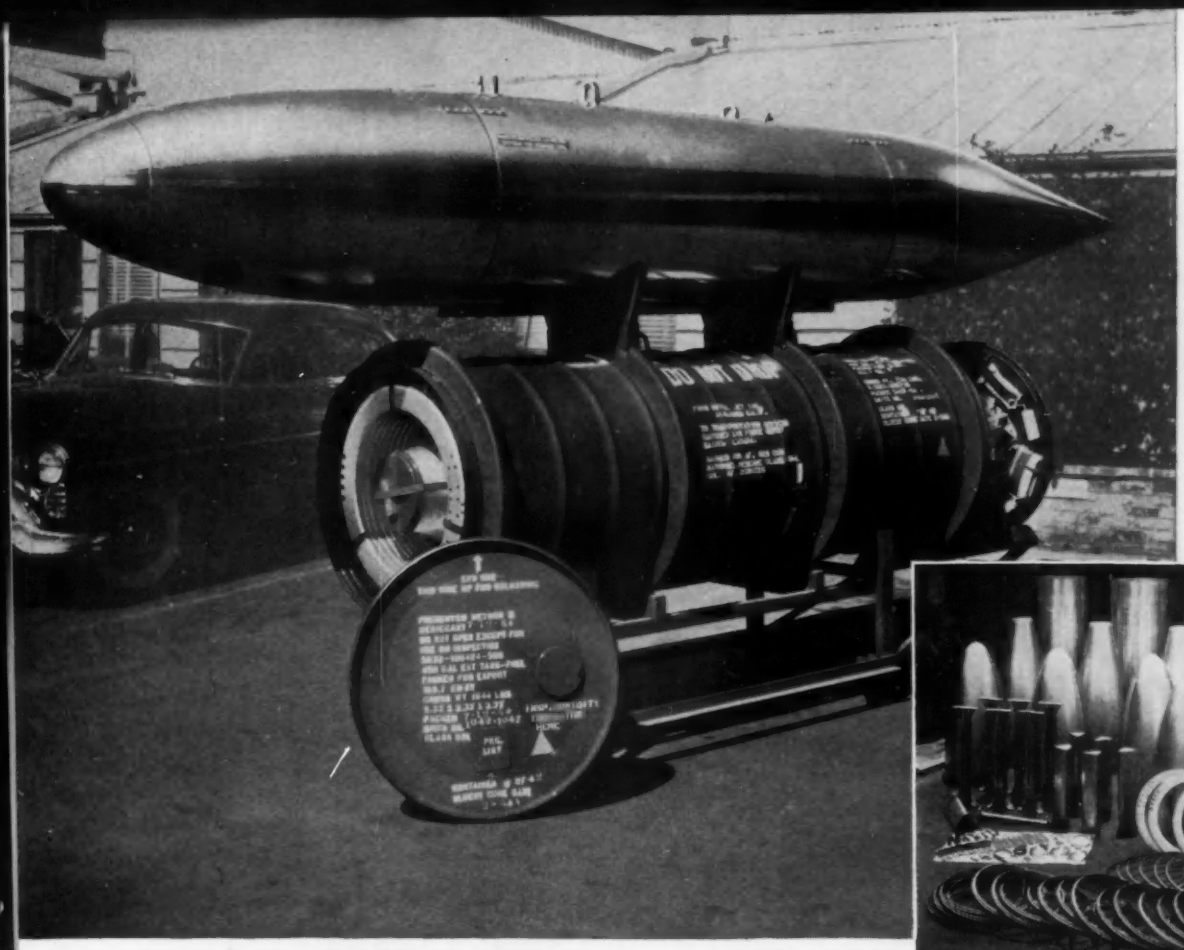
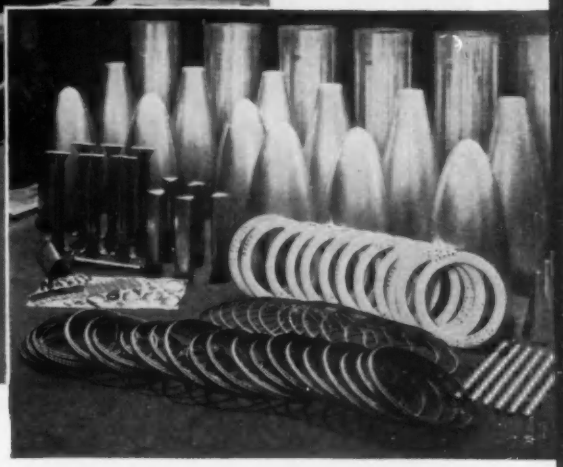


This picture shows a COR-TEN Steel container and an assembled wing tank mounted on it for display purposes.

(Below) All these components for six 450-gallon wing tanks are ingeniously nested and carried in a single Royal Jet Tank Can made of USS COR-TEN Steel. Tanks can be easily and quickly assembled in the field.



How containers for jettisonable fuel tanks—made of USS COR-TEN Steel—save 40% in shipping and storage space—reduce weight 25%—cost 10% less than crates

Shipped six-at-a-time in these COR-TEN Steel "cans," 450-gallon wing tanks for jet aircraft now travel more safely and more cheaply to their distant destinations. Not only are they better protected than ever before against shipping and landing hazards but they are indefinitely preserved in storage.

Royal Jet, Inc. of Alhambra, Calif., developer, designer and manufacturer of these efficient containers, has found COR-TEN Steel the most satisfactory material from the standpoint of lightweight, permanence, ease of manufacture and reasonable cost.

For with USS COR-TEN Steel which is 50% stronger than carbon steel and offers 4 to 6 times greater resistance to atmospheric corrosion they can use light 12 ga. and 18 ga. sheets to build containers of great strength and ruggedness that weigh 25% less than wooden crates.

These steel containers offer other advantages, too. Hermetically sealed and filled with dry air they contain sufficient dessicant to insure minimum moisture content. Since no organic materials are used in the padding, fungus growth and interior corrosion are eliminated. As a result the sealed-in tanks stay factory-new regardless of temperature, climate or length of storage. Containers can be stored in the open for an indefinite period with a minimum of damage or deterioration.

This new packaging technique pays off. By replacing wooden crates, formerly used, with these COR-TEN Steel containers, weight per wing tank shipped has been materially reduced, 40% less storage and shipping space is required and the shipping cost to Europe, for example, has been reduced $21.36 per tank —a saving to the Government, on only 100,000 tanks, of more than $2,000,000.

SOON TO BE ISSUED. Our new "Design Manual for High Strength Steels" contains comprehensive and practical information that you will find extremely useful in designing your product for greater economy and efficiency by the use of high strength steels. Watch our future advertisements for the announcement of the availability of this important publication.

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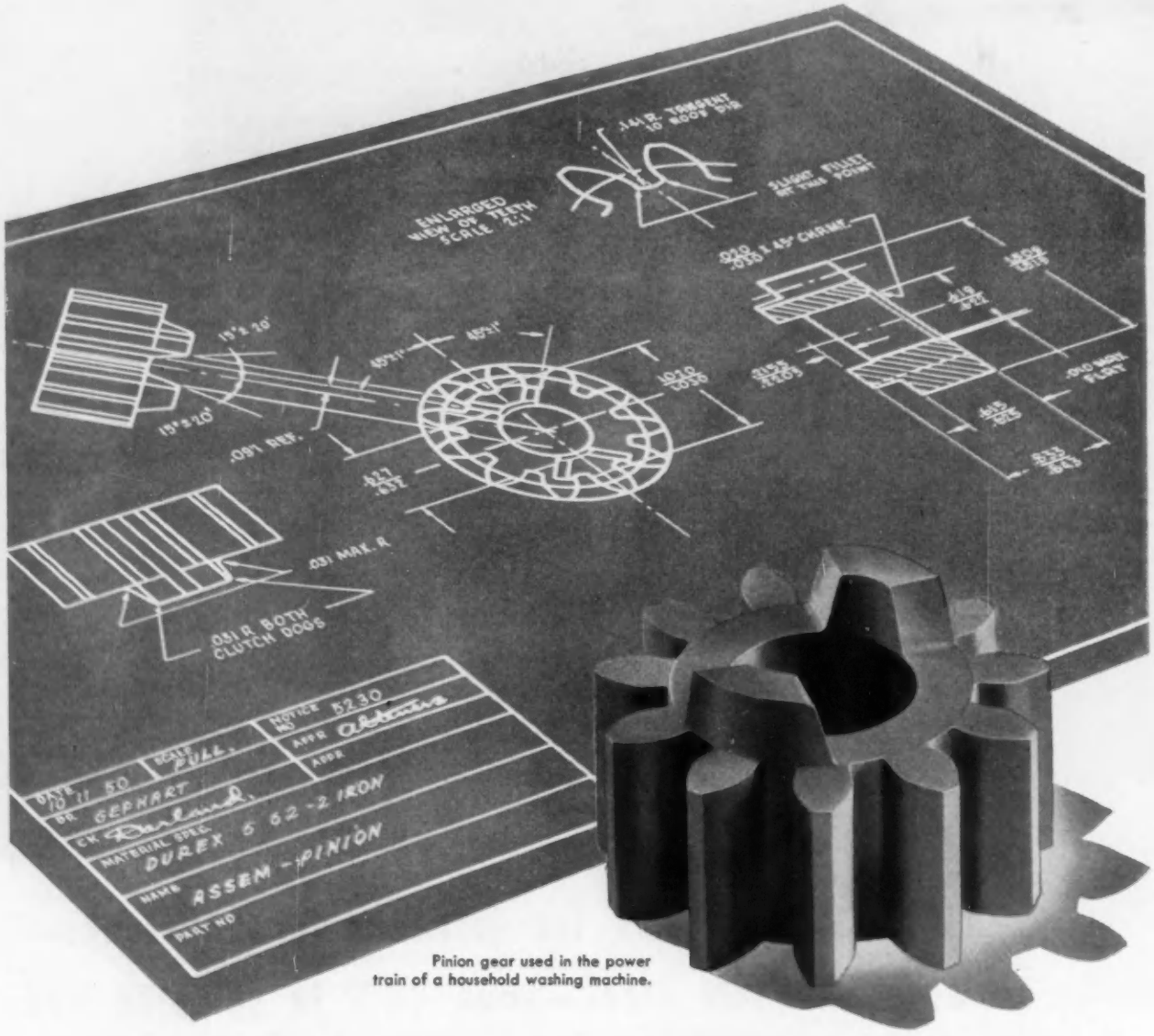
USS COR-TEN HIGH Strength STEEL

USS

S-440

UNITED STATES STEEL



Pinion gear used in the power train of a household washing machine.

MORAINE METAL POWDER PARTS SOLVE MANY PRODUCTION PROBLEMS

Here you see a complex design that is being mass-produced today by metal powder techniques *with important savings in cost.*

The print in the background indicates the intricacy of the design, while the photograph in the foreground shows the part ready to be assembled into the final mechanism. And from raw material to what you see here took only *one press operation!* This demonstrates what has come to be expected through cooperation between customer and Moraine.

Moraine's experience with metal powder is called upon almost daily to resolve complex designs into economical production jobs—just as Moraine almost daily contributes to modern industry by improving product performance and lowering costs.

moraine products
DIVISION OF GENERAL MOTORS, DAYTON, OHIO

METAL POWDER PARTS

STARTLING... the heat resistance of this new plastic film

CHALLENGING to industry... the combination of remarkable properties offered by Du Pont MYLAR*

The amazing stability at extremes of heat and cold is just one of the properties of "Mylar" polyester film that may help you improve a product.

"Mylar" is also the strongest plastic film available.

Its thinness can save you space in the design of equipment.

Its outstanding dielectric strength makes it an ideal insulating material.

Its resistance to moisture and many solvents further increases its range of applications. Laminated to other plastics, to metal foils or papers, it makes vapor barriers . . . decorative and protective laminates.

What about *your* product? This remarkable combination of properties presents a challenge—but a rewarding one—to the research brains of your organization. Better products . . . lower costs . . . a real competitive edge . . . these are the advantages that "Mylar" offers. Send the coupon for your copy of a new booklet that shows how this versatile film may help you cut costs, increase efficiency. Write to: E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Wilmington 98, Delaware.

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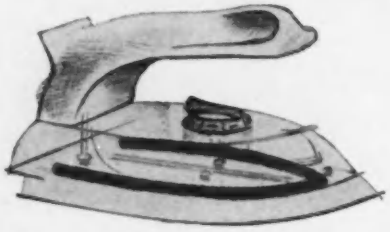
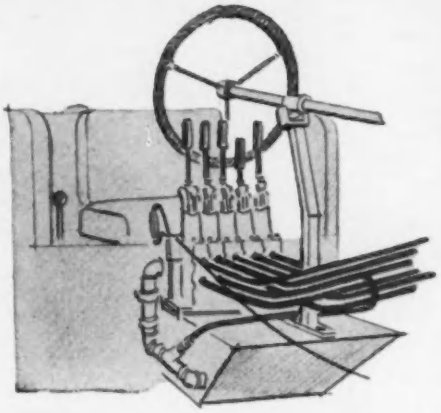
BUNDY TUBING COMPANY

FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*



SHEATH FOR HEATING ELEMENT IN HAND IRON

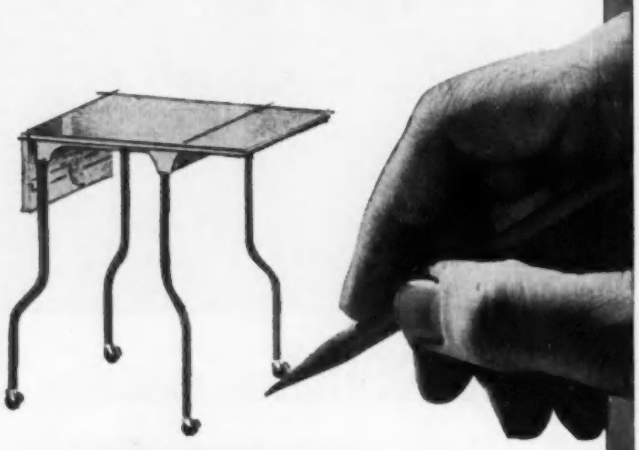


HYDRAULIC CONTROL GROUP IN ROAD GRADER

REMARKS Designing a new product? Or redesigning an old one? Why not avoid delays, expense by turning your tubing headache over to our engineering experts. They offer you a wealth of problem-solving experience, plus the priceless bonus of Bundyweld, the only tubing double-walled from a single strip (see below).

WRITE today for catalog or for help in developing your tubing application.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN



FRAME FOR TYPING TABLE

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness,

and passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

- Leakproof
- High thermal conductivity
- High bursting point
- High endurance limit
- Extra-strong
- Shock-resistant
- Ductile
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- Takes plastic coating
- Takes plating
- Bright and clean
- No inside bead
- Uniform I.D., O.D.

Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Los Angeles 58, Calif.:* Tubesales, 5400 Alcoa Ave. • *Philadelphia 3, Penn.:* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South *Toronto 5, Ontario, Canada:* Alloy Metal Sales., Ltd., 181 Fleet St., E. • **Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.**

DOW CORNING CORPORATION

Silicone News

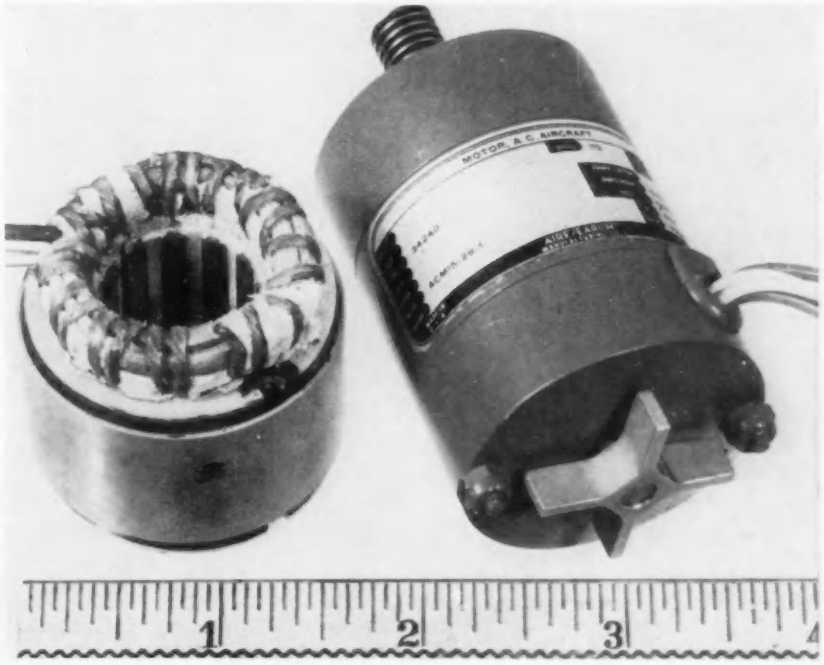
FOR DESIGN ENGINEERS No. 13

Silicone Aluminum Paint Protects Jet Engine Combustion Chambers

The materials used in many of the combustion chambers and burner supports manufactured for J-35 jet engines by Solar Aircraft of Des Moines, must remain unaffected by abnormally high temperatures. Aluminum clad steel solves the problem satisfactorily with exception of various fusion welds. These must be recoated with aluminum or a noncorrosive coating that will withstand up to 800 F.

Solar engineers have the answer to that problem, too. They simply spray or dip the welded part with two coats of Sicon, an aluminum paint formulated with Dow Corning silicone resins by Midland Industrial Finishes.

After a one hour bake at 400 F, the silicone based coating provides the required protection. According to Solar, this is one of the most satisfactory paints for use on jet engine parts. *No. 127*



SILICONE INSULATION ADDS LIFE, CUTS SIZE OF MINIATURE MOTOR IN B-52A BOMBER

PROBLEM:

Ambient temperatures range from —65 to 300 F.

Size and weight must be held to a minimum.

Maximum reliability is imperative.

To meet those requirements, design a miniature a-c motor for continuous duty in the oil temperature controller for the Boeing B-52A Stratofortress.

SOLUTION:

Design engineers with the AiResearch Manufacturing Division of The Garret Corporation found the best solution to that problem in electrical insulating materials and high temperature paints made with Dow Corning silicones. Dow Corning 33 Grease solved the bearing problem.

A silicone bonded asbestos-glass laminate, made by the Irvington Varnish and Insulator Company is used for slot and phase insulation. Dow Corning Sylkyd enameled magnet wire, manufactured by Hi-Temp Wires, Inc. is used in the windings. Silicone-glass laminate is used for end laminations and slot wedges. End connections are tied with Silastic-impregnated glass cord.

Silastic-impregnated Turbo 117 glass sleeving, made by William Brand and Company, is used to insulate the connections because of its flexibility and outstanding resistance to fraying.

(Cont. pg. 2)

SILICONES IMPROVE LICENSE PLATE APPEARANCE AND SERVICE LIFE

Next time you see one of the 4,000,000 vehicles bearing the white on green 1955 Michigan license plate, note the smoothness and gloss of the green background. That's because the paint, supplied by the Saginaw Paint Company of Saginaw, Michigan, was formulated with Dow Corning 200 Fluid. Addition of less than 1% of the silicone fluid helped reduce sags and wrinkles during dipping and increased color retention and resistance to weathering and snow removal chemicals. *No. 128*

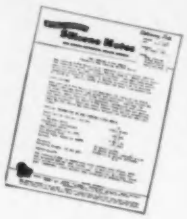
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . .



New 1955 Reference Guide to Dow Corning silicone products gives in 8 pages a brief but comprehensive summary of the properties and applications for the silicone products that are most widely used. Products are indexed by type of application. With increasing effort devoted to product improvement and cost reduction, such a reference guide to this remarkably stable group of engineering materials becomes increasingly important to design, production and maintenance engineers. *No. 132*

Silicone Foaming Powders produce heat-stable, nonflammable, easily machined, low density foam structures for electrical and thermal insulation. Supplied ready to use, they can be foamed in place and often cured in service. Recently published data sheet gives applications, properties and foaming characteristics. *No. 133*

Dow Corning R-4010 Resin is a silicone water repellent coating that markedly improves wet insulation resistance of Class A or Class B electrical equipment. Easily applied by dipping, spraying or brushing, it air dries tack-free in 20 to 30 minutes and cures within 24 hours. *No. 134*

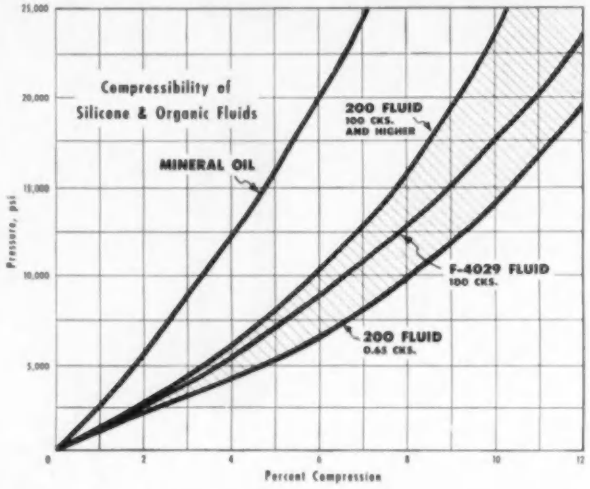
"New Developments in Silicones" is a 16 page progress report which appeared in a recent issue of MACHINE DESIGN. A complete review of the silicone products most useful to designers, the article provides data and illustrates applications for silicone foams, protective coatings, rigid laminates, dielectrics, lubricants, rubber and adhesives. Reprints available. *No. 135*

Dow Corning 36 Emulsion is a completely new silicone mold lubricant. Much more stable than any comparable silicone emulsion, it gives molded parts a superior surface finish. Its stability is attributable to an average particle size of less than 0.5 microns. At concentrations in the range of 1 part emulsion to 100-200 parts water, Dow Corning 36 Emulsion gives clean, easy release of rubber or plastic moldings and cost metal parts. *No. 136*

DESIGNERS USE SILICONE FLUIDS FOR MORE EFFICIENT SPRINGING

Dow Corning silicone fluids have always been noted for their thermal stability and their remarkably flat viscosity-temperature slopes. They have, therefore, been widely used as damping media in such devices as dashpots, overload relays and torsional vibration dampers for crankshafts.

More recently, designers have found that certain silicone fluids, Dow Corning F-4029 and some Dow Corning 200 Fluids, also have high compressibility. Using these fluids, engineers have produced liquid springs and shock absorbers with the same capacity as much larger and heavier metal coil springs. Testing indicates these highly compact liquid springs retain a high order of efficiency even under constant recycling at milli-second intervals.



As shown in the graph, both Dow Corning F-4029 and the Dow Corning 200 Fluids are more compresible than the mineral oil commonly used in liquid springs. At 20,000 psi, F-4029 has a compressibility of 10.8% which is mid-way between that of Dow Corning 200 Fluids of the same and of lower viscosity grades. While it lacks the compressibility of the lower viscosity 200 Fluids, Dow Corning F-4029 is less volatile and has a lower viscosity-temperature coefficient. *No. 130*

Westinghouse Seals New Switches With Silastic for Sub-zero Service

Sealed, top and bottom, with Silastic gaskets, the new Westinghouse gas-filled, load interrupter switches remain operable at temperatures as low as —65 F. Organic rubber seals were originally tried, but sub-zero weather caused the seals to harden and shrink, allowing the sulfur hexafluoride gas to escape.

On testing, Westinghouse engineers found that Silastic gaskets easily passed all pressure, vacuum, and temperature requirements, and were not affected by the gas. The Silastic gaskets provide such a tight seal that Westinghouse expects the units to hold gas pressures of 30 psi indefinitely without recharging. *No. 131*

MINIATURE MOTORS *(Continued)*

The stator is impregnated with Dow Corning 997 silicone varnish and baked at 400 F. The stator bore is painted with Sicon black silicone enamel, manufactured by Midland Industrial Finishes.

The ball bearings are lubricated with Dow Corning 33 silicone grease to give long service at temperatures ranging from —65 to 300 F. *No. 129*

Dow Corning Corporation, Dept. 8602, Midland, Michigan

Please send me: 127 128 129 130 131 132 133 134 135 136

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MIDLAND MICHIGAN

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DOW CORNING SILICONES

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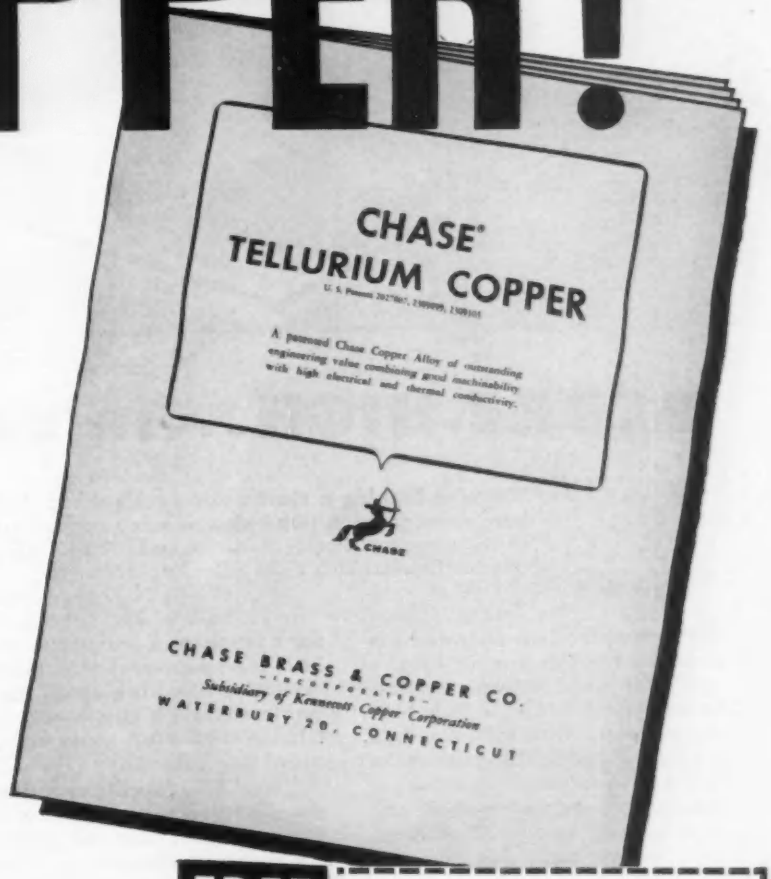
Has high conductivity, good machinability... saves production time!

Chase Tellurium Copper gives you the advantages of high conductivity *plus* good machinability.

Chase Tellurium Copper can be machined with tool speeds and settings similar to those used with Free-Cutting Brass, permitting high rates of production. But, unlike Free-Cutting Brass, Chase Tellurium Copper can be *hot worked* easily, and can be cold worked almost as extensively as pure copper.

For more information on Chase Tellurium Copper, check the coupon below.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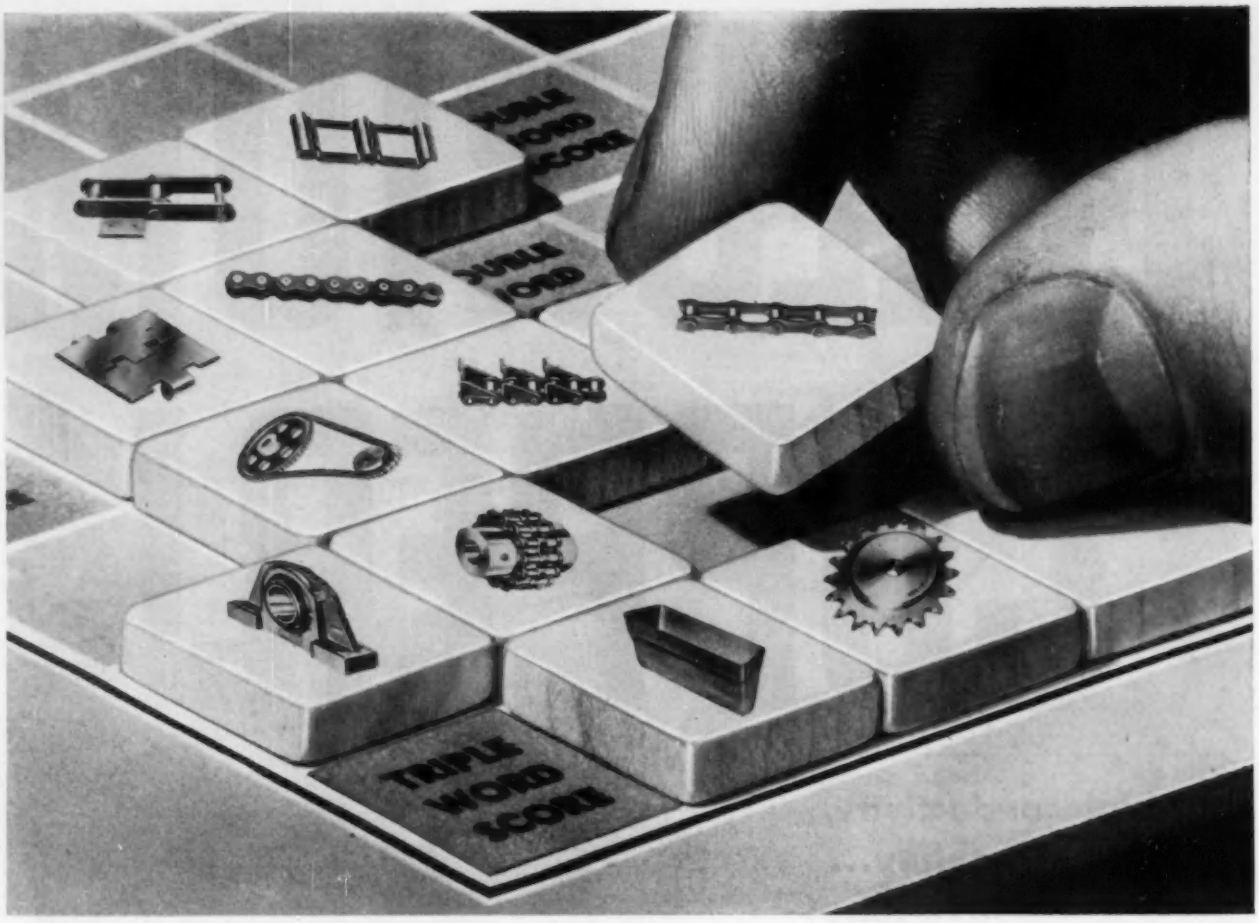

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If you have a problem of designing for lower cost, or improving efficiency or appearance, consult your CHAIN Belt Man. Fit into your board the *complete* CHAIN Belt line with the exact chain, attachment, sprocket, flexible coupling or self-aligning bearing to solve your particular problem. Call or write CHAIN Belt Company, 4715 W. Greenfield Ave., Milwaukee 1, Wisconsin.

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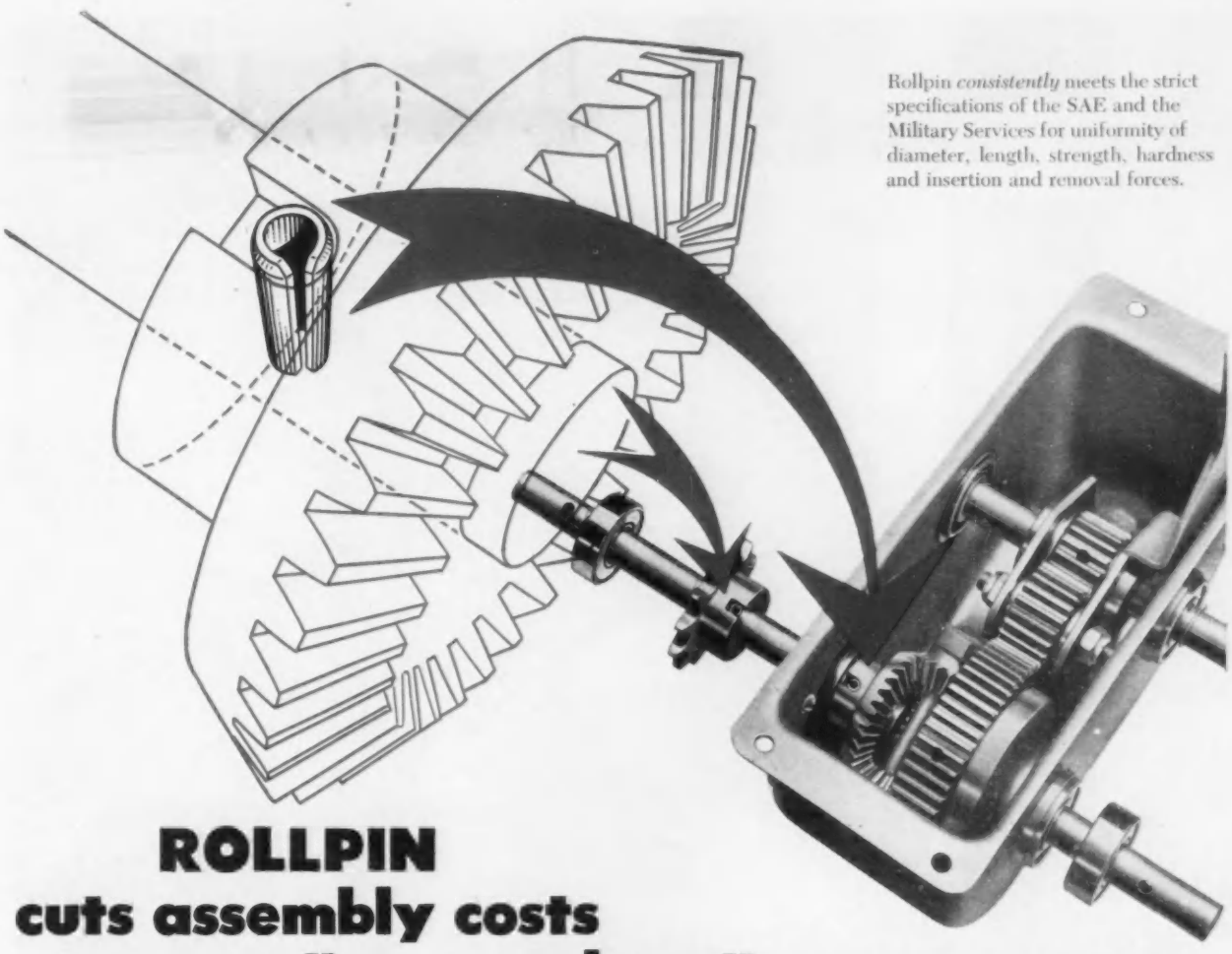

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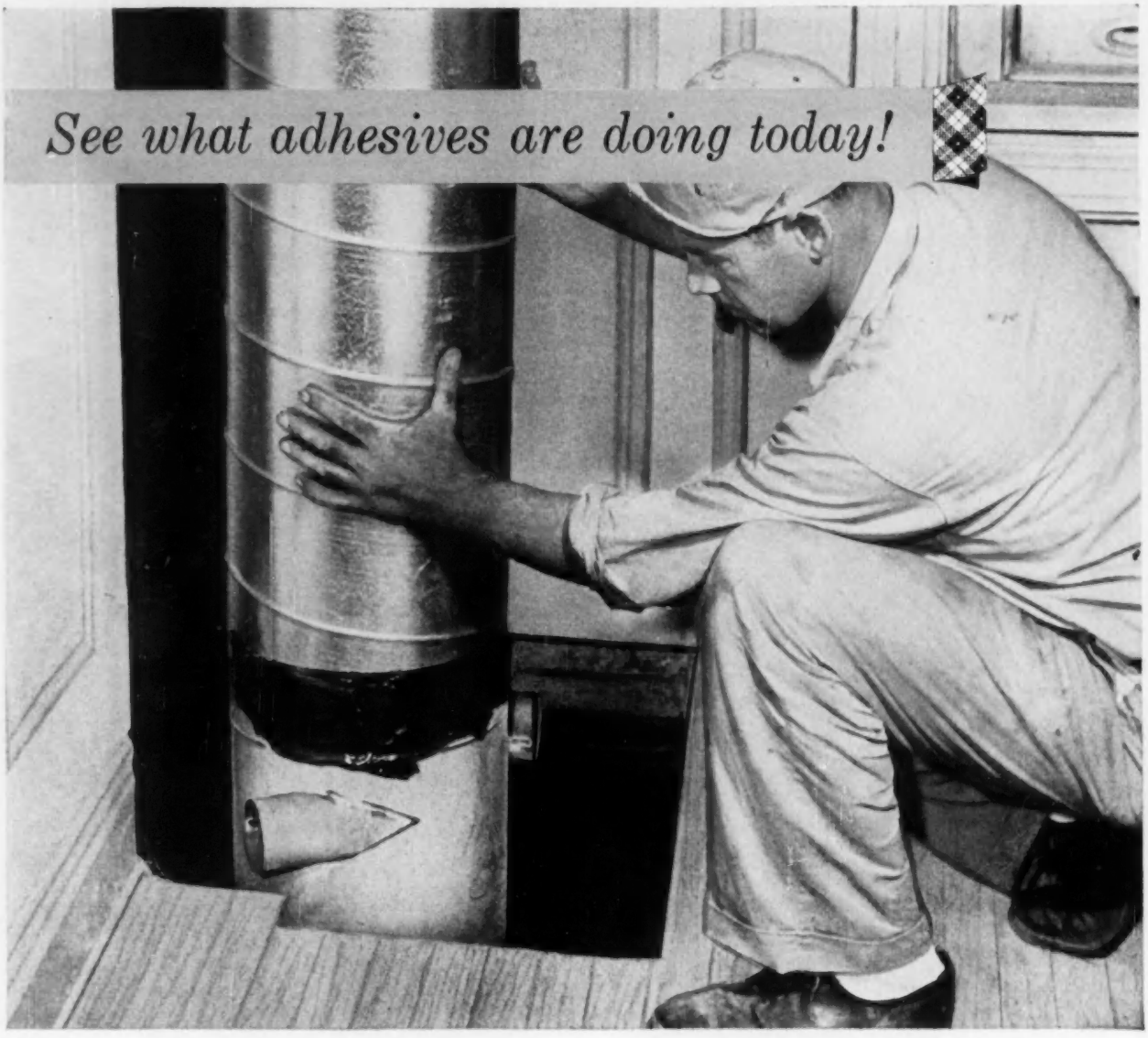

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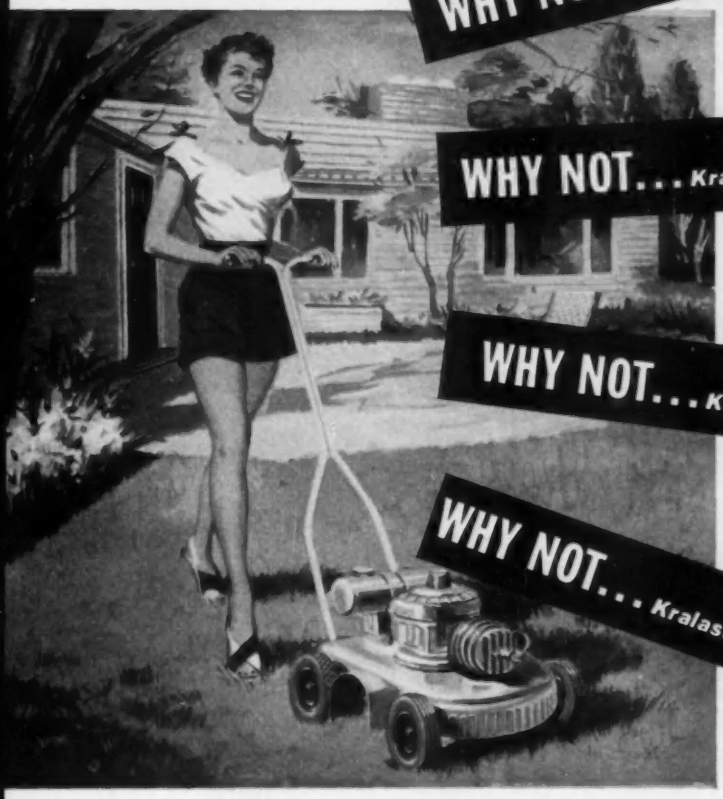

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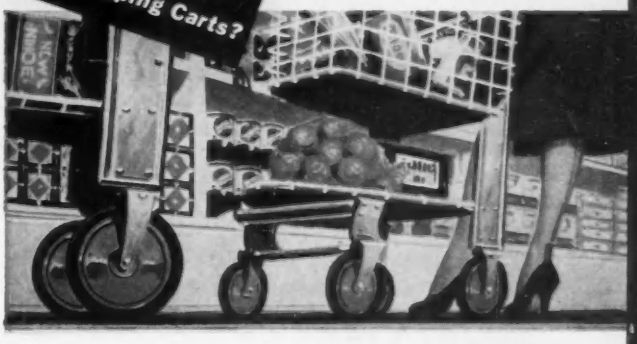

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DO YOU KNOW? Standard FLEXLOCS smooth off rough bolt threads. The locking threads on all-metal FLEXLOCS are not chewed up when used on rough bolts.

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Standard FLEXLOCS are one piece, all metal. They are not affected by temperatures to 550°F. Nuts lacking these features have a more restricted temperature range.

Standard FLEXLOCS lock securely—stopped or seated—when 1½ threads of a standard bolt are past the top of the nut.

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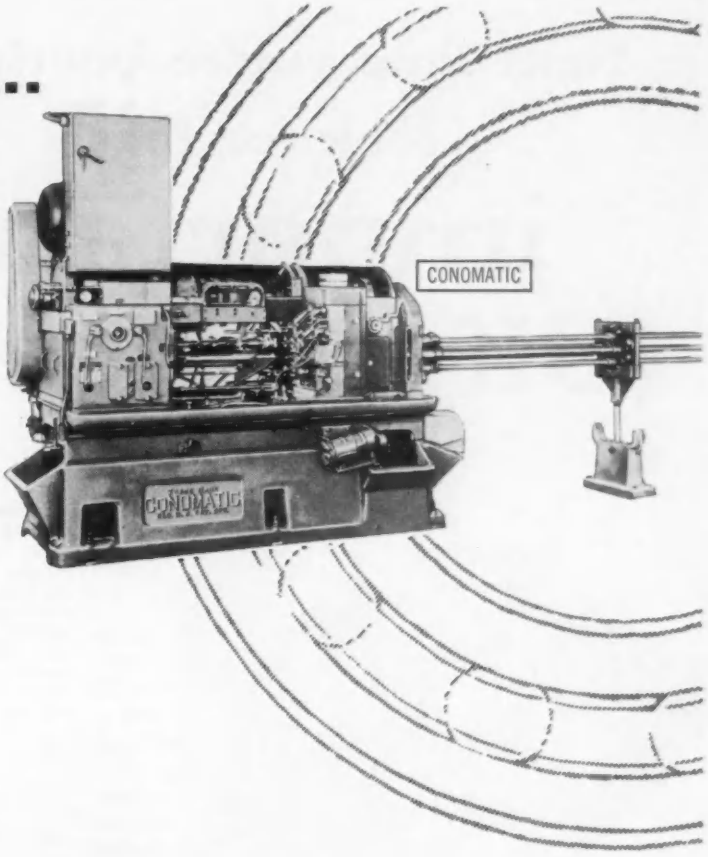

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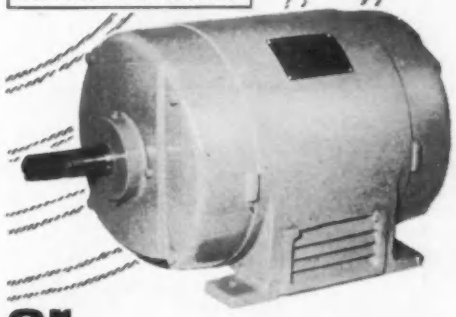

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The smooth hum of today's precision-built motors whispers the efficiency of every part. Here, too, Federal Ball Bearings quietly perform their continuous, anti-friction assignment—whatever the size—whatever the type.

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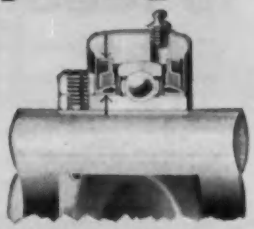

POSITIVE PROTECTION from moisture, dust and dirt is accomplished by seals extending from housing to inner ring. All aligning surfaces are enclosed in lubricant chamber.

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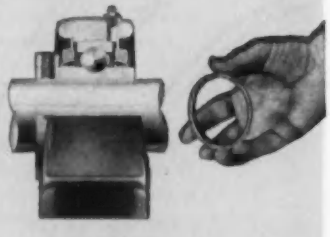

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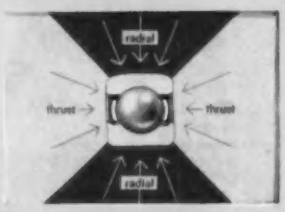

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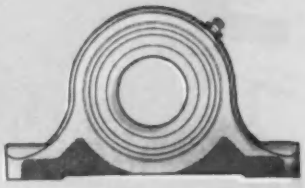

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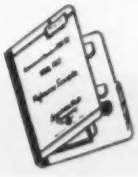

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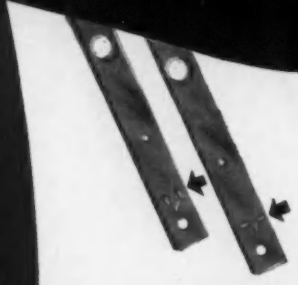

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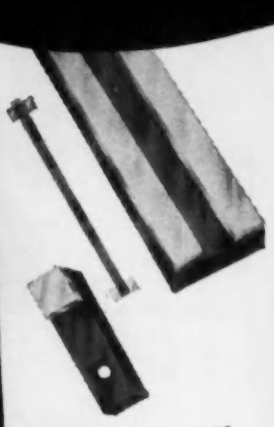
First used for miniature relays in telephone service, they now find widespread application in the current trend toward miniaturization. An important factor for easy, swift assembly is the fact that alignment of contacts is not critical.

Attachment by Makepeace machines effects major savings because they cut off and weld automatically. Further economies in precious metals result from the fact that laminated precious metal capped contacts are produced on tape in production runs and supplied on reels . . . eliminating need for handling individual tips.

For more than half-a-century, Makepeace has specialized in the production of finely finished laminated and solid precious metals. These are constantly held to the closest possible tolerances . . . have earned Makepeace the reputation of being the central source of supply for materials which meet the most exacting specifications. Three Makepeace developments that fulfill rigid requirements for electrical qualities, corrosion resistance, economy and longer effective service life are here briefly described.



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Here is a prime method for reducing costly assembly operations to blanking costs. Contacts made from Makepeace raised lay materials have greater hardness in both the bare metal and the contact tip in addition to longer life through being work-hardened. Any number of strips of sliver may be bonded to base metal. Cold hard rolling produces dense contact surfaces for the most desirable electrical and mechanical qualities.

SPOT LAY*

This patented Makepeace process brazes slugs of precious metals in strip stock, positioning them exactly where required. Exclusively Makepeace, Spot Lay enables manufacturers of rotors in switches and small bridge contacts to secure material with lower end cost and greatly improved life performance.

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DESIGNING WITH ALUMINUM

NO. 10

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

ALUMINUM SOLDERING

ALUMINUM has been considered to be a difficult metal to solder, but this is not true today. Aluminum can be readily soldered by using the commercially available materials and any of the soldering procedures commonly used with other metals.

Soldering Aluminum

Aluminum can be satisfactorily soldered for many applications by using a soldering iron, torch or furnace, or by employing dip or resistance soldering procedures. The surface oxide film can be readily removed by abrasion, ultrasonics or by using either a reaction or organic flux. The solder usually is an alloy of zinc containing one or more of the elements aluminum, cadmium, copper, silver, tin or lead. Aluminum soldered joints exhibit excellent mechanical properties and their corrosion resistance is determined by the composition of the solder. In general, the high zinc content solders develop the best corrosion resistance; soldered aluminum systems made with these solder alloys are still very serviceable after 7 years' outdoor exposure to an industrial atmosphere.

Parent Alloy

The solderability of aluminum alloys varies considerably with the amount of alloying constituents present. All aluminum alloys can be soldered by the employment of either abrasion or ultrasonic soldering techniques. However, if a flux is employed to remove the oxide film, the choice of aluminum alloys is restricted to those containing less than 4% silicon or 3% magnesium. For this reason, the alloys most commonly soldered are EC, 1100 (2S), 3003 (3S), 5005 (K155), 5050 (50S), 6061 (61S) and Kaiser Aluminum Utility Sheet.

Soldering Fluxes

There are two general types of aluminum soldering fluxes commercially available. The first type, called a reaction flux, relies on the reaction of a metal halide, such as zinc chloride or tin chloride, to remove the oxide film. This type of flux is generally preferred for soldering alloys containing magnesium or for soldering at temperatures of 650°F or higher. Reaction type fluxes are readily used in most soldering operations. However, the flux residue is capable of accelerating corrosion and it should be removed by thorough washing after the soldering operation is complete.

The second type of flux widely marketed is a chloride-free organic flux. This flux is normally useful only for low temperature soldering operations. The flux residue does not materially accelerate corrosion. Hence, organic fluxes have been used successfully in some commercial applications where the removal of flux residue is impracticable.

Fig. 1. This photograph shows an aluminum cable being soldered by immersion in a bath of molten solder. Using fluxes developed by Kaiser Aluminum, it is as easily dip soldered as the most soluble metals.

TABLE I Typical Compositions of Solders Commonly Used to Solder Aluminum

Alloy	Solder	% Sn	% Zn	% Pb	% Cd	% Al	% Cu	Melting Temperature*	Corrosion Resistance
1	Zinc Base		96.2			3.8		750	Best obtainable
2			94			4	2	740	Best obtainable
3			81.6	3	.4	10	5	750	Good
4	Tin Containing	28.2	70.9	.6			.3	710	Suitable for most indoor and some outdoor applications
5		64.9	35.1					615	"
6		50	15	.5	31.5	3		570	"
7	Lead Containing	40.6	21	37.7			.7	680	Must be protected outdoors but suitable for many indoor applications
8		31.7	9	51	8		.3	485	"
9		50	21.5	28.5				640	"

*Temperature at which the solder is completely liquid.

Alloys 1, 2 and 3 are widely used as abrasion type solders and are best applied using a gas torch. In addition, they can be used with reaction type fluxes and the commonly used sources of heat.

Alloys 4, 5 and 6 are general purpose alloys and are usually used with reaction type fluxes although they can be used with the organic types of fluxes if care is taken to avoid overheating. Torch, furnace and dip soldering procedures are generally used with these alloys.

Alloys 7, 8 and 9 are frequently used with the organic type of flux in low temperature soldering operations. These solders can be used with any of the common sources of heat, including the soldering iron.

Solders

The commercial solders can be classified into three general groups. The first group consists of alloys of zinc containing 3 to 10% aluminum and small amounts of other metals such as copper, silver and iron. This group of solders form the most corrosion resistant soldered assemblies, but they require soldering temperatures of 750°F to 800°F. The mechanical strength of joints made with the high zinc solder is excellent.

The second group of solders contain zinc and tin with small additions of copper, lead, cadmium or silver. They require soldering temperatures of 650°F to 750°F. These solders are general purpose materials and are extensively used by industry for those applications requiring a fairly simple soldering operation but where some sacrifice in corrosion resistance is permissible. The mechanical strength of

PLEASE TURN TO NEXT PAGE ➡

joints made with these solders is satisfactory for most applications; the shear strength will range from approximately 8,000 to 15,000 psi (pounds per square inch) of soldered area.

The third group of solders contain tin and zinc with major additions of lead and/or cadmium. These solders are characterized by low melting temperatures, which in turn permit low soldering temperatures of 450°F to 650°F. The shear strength of the soldered joints approaches that of soft soldered joints made in copper, i.e. about 7,000 psi. These solders produce joints having the lowest corrosion resistance but they are the easiest to use in a soldering operation.

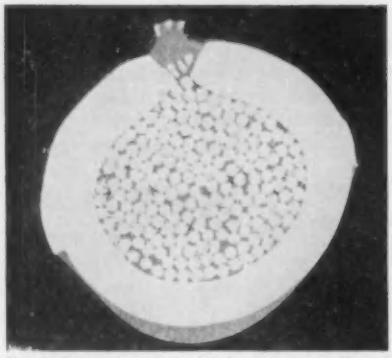

Fig. 2. Photomicrograph showing a cross section of an aluminum cable soldered by immersing it in a molten bath of 70% Zn 30% Sn solder using a liquid flux developed by Kaiser Aluminum. 5X.

Soldering Procedure

The fundamental operations involved in soldering are simple. The surface oxide film is removed and molten solder flowed over the clean surface to form a bond with the parent metal.

The first step in a soldering operation is the removal of the extraneous dirt and grease present on the surface. The commonly soldered aluminum alloys can be easily cleaned with organic solvents such as alcohol, carbon tetrachloride, etc. If the surface is badly weathered it should be wire brushed. The clean metal can then be soldered using either manual or mechanized soldering procedures commonly used for soldering other metals. The actual choice of solder, fluxes and soldering procedure will depend upon the specific joining problem at hand.

For manual soldering operations, gas torches, resistance tongs, or a molten bath of solder are commonly used as heat sources. Gas or electrically heated soldering irons find limited use for soldering thin aluminum assemblies or relatively small articles. A flux is generally used to remove the oxide film when using any of the heat sources mentioned. The solder can be either manually fed into the joint by using a rod of solder or it can be preplaced in the joint in the form of shims, rings, washers, etc. Ultrasonic vibrations have recently been introduced as a means of removing the oxide film on aluminum. Such vibrations currently have some limited use when dip soldering in a bath of solder. Furthermore, specially constructed ultrasonic soldering irons are being used fairly successfully. When soldering with a torch or ordinary soldering iron, it is also possible to use abrasion to remove the oxide film. This can be done by heating the aluminum with a torch or iron to the soldering temperature, melting a small amount of solder on the surface, and then removing the oxide film by abrading it with steel wool or a wire brush. Alternatively, a specially alloyed solder marketed as abrasion or friction solder may be rubbed directly on the surfaces to be soldered. If this is done, the oxide film is removed and the aluminum is coated with solder in one operation.

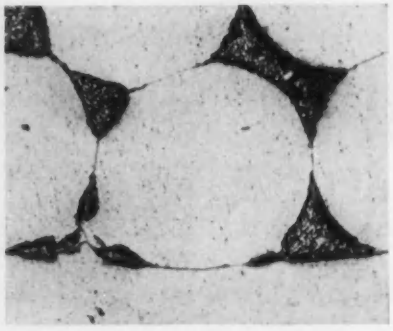

Fig. 3. This photomicrograph at 100X shows an enlarged section of the cable shown in Fig. 2. The solder has filled the interstices of the cable and joined the individual strands to each other to provide an electrical joint of minimum resistance.

In mechanized soldering operations the heat sources are usually multiburner torches, resistance tongs, a molten solder bath, electric resistance furnaces or electrical induction. A flux is usually used to remove the oxide in mechanized operations. The solder is preplaced in the joint using the common forms of preplaceable material, such as shims, washers, etc. Another effective method is to "pre-tin" at least one of the surfaces to be soldered to produce a coating of solder on its surface. This solder coating will melt when heated and it furnishes the solder necessary to fill the joint. Recently, some use has been made of ultrasonic vibrations applied directly to the dip soldering bath for removing the oxide film. In general, mechanized soldering operations should be completed in the shortest time possible to minimize warpage. The maximum speed attainable is determined by equipment limitations, although soldered aluminum joints have been made at speeds of over 200 feet per minute.

Corrosion Resistance

Soldered aluminum assemblies corrode because of the galvanic cell which results from the difference in electrode potential between the aluminum and the solder. These galvanic cells can be likened to small batteries in which the aluminum is the anode, the solder is the cathode, and the corrosive medium is the electrolyte. The current flowing in such a simple cell will be determined by the potential difference between the anode and cathode and the electrical resistance of the cell. If this analogy is correct, those metals having electrode potentials close to that of aluminum would make the most corrosion resistant soldered assemblies. On the other hand, those having the greatest potential difference would make the least corrosion resistant assemblies. In addition, we would expect the corrosion rate to be greatest in electrolytes or corrosion media which are good conductors of electric current. Conversely, corrosion would be the slowest in those which are poor conductors of electricity. In general we find this is true. The electrode potential of zinc is close to that of aluminum, and solders containing high percentages of zinc provide the most corrosion resistant soldered joints. Conversely, both lead and tin have potentials that are more widely separated from aluminum; hence, they provide a system having poor corrosion resistance. Therefore, the tin-lead solders commonly used with other metals are not suitable for soldering aluminum unless the assembly is protected from corrosive environments. In addition, we find that the corrosion rate is greatest in good electrolytes, such as salt solution, and is least in a poor conductor, such as pure water. Corrosion stops entirely when the assembly is exposed to dry air, under which condition no electrolyte is present.

More detailed assistance with design, alloy selection and fabrication procedures are obtainable through the Kaiser Aluminum sales office listed in your telephone directory, or through one of our many distributors. Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office:* Palmolive Bldg., Chicago 11, Ill.; *Executive Office:* Kaiser Bldg., Oakland 12, California.

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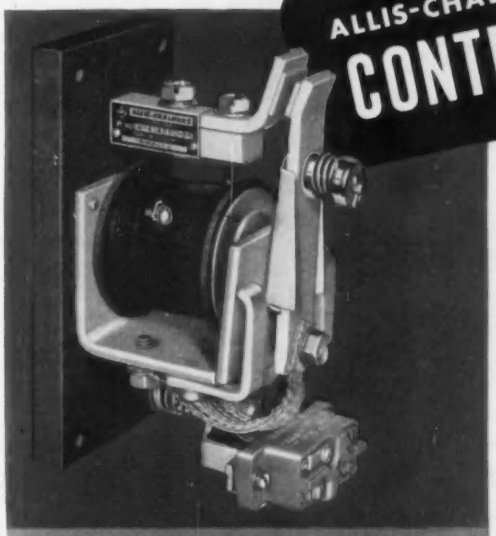
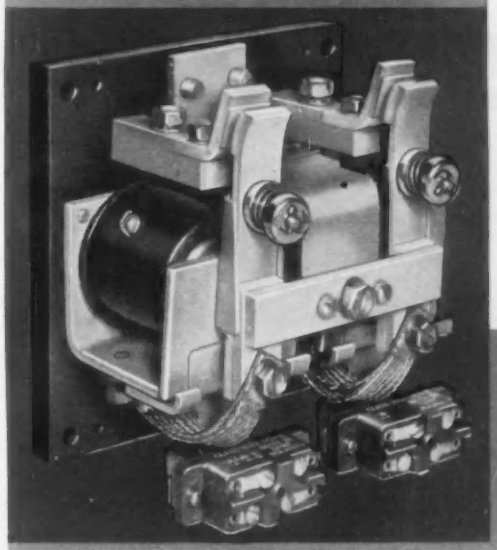


Type 264 single-pole general-duty contactor



Type 264 reversing general-duty contactor

Acceleration, reversing, timing, plugging, switching. Allis-Chalmers Type 264 can be used singly for any of these tasks. Group-mounted, they perform several or all of these functions. This versatility, coupled with a compact design, provides equipment manufacturers with a new measure of control flexibility. Performance-proved on electric industrial trucks, cranes and hoists, these dc contactors may be applied wherever dependable intermittent duty is essential . . . wherever installation space is at a premium. Type 264 contactors are rated 200 and 400 amps at 36 volts.

Check these advantages

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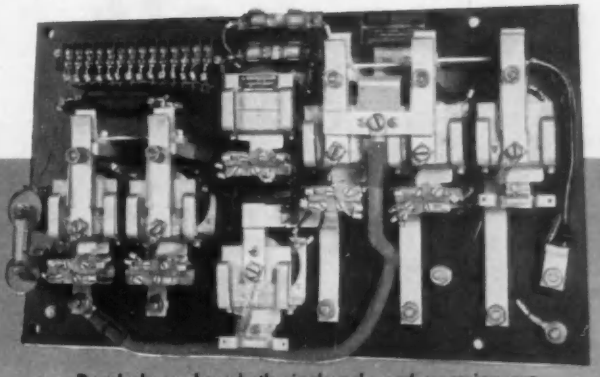

A-4400

Panel shows how both single-pole and reversing contactors may be mounted to perform several functions.

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Type 264 contactors are typical of the standard, modified standard and special controls designed and produced by Allis-Chalmers.

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For details, call your District Office or write Allis-Chalmers, Milwaukee 1, Wis.

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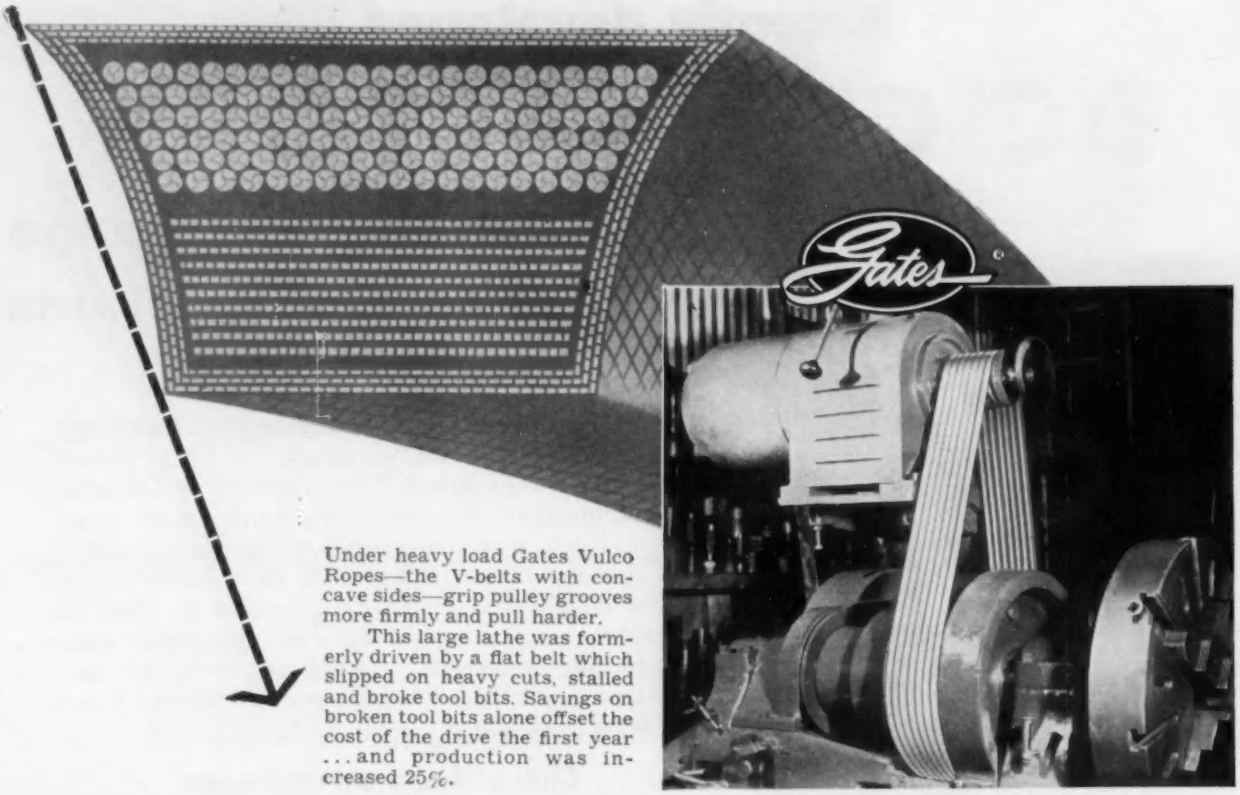

Under heavy load Gates Vulco Ropes—the V-belts with concave sides—grip pulley grooves more firmly and pull harder.

This large lathe was formerly driven by a flat belt which slipped on heavy cuts, stalled and broke tool bits. Savings on broken tool bits alone offset the cost of the drive the first year ...and production was increased 25%.

Concave sides keep belt costs down!

Industry is saving thousands and thousands of dollars every year by specifying Gates Vulco Ropes—the V-Belts with *concave sides* (U.S. Pat. No. 1813698).

Here's the interesting reason *why* Gates belts save money:

On the bend around the sheave the *precisely engineered* concave sides (Fig. 1) of the Gates belt fill out and become straight (Fig. 1-A). Thus the belt makes uniform contact with the sides of the pulley. That means sure pulling power and *even distribution of wear.* Longer wear, fewer replacements cut belt costs...reduce down time...contribute to profits.

Simple test proves value of concave sides

Bend a straight-sided belt (Fig. 2) and feel the sides *bulge out* around the bend. The bulging sides prevent the belt from fitting evenly in the pulley groove (Fig. 2-A). Uneven contact causes uneven wear...shortens belt life...increases costs.

Keep belt costs *down* by specifying Gates Vulco Rope Drives—the V-Belt with *concave sides.* Belts you need are readily available from nearby distributor stocks. The Gates Rubber Company, Denver, Colorado—*World's Largest Maker of V-Belts.*

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TPA 25-A

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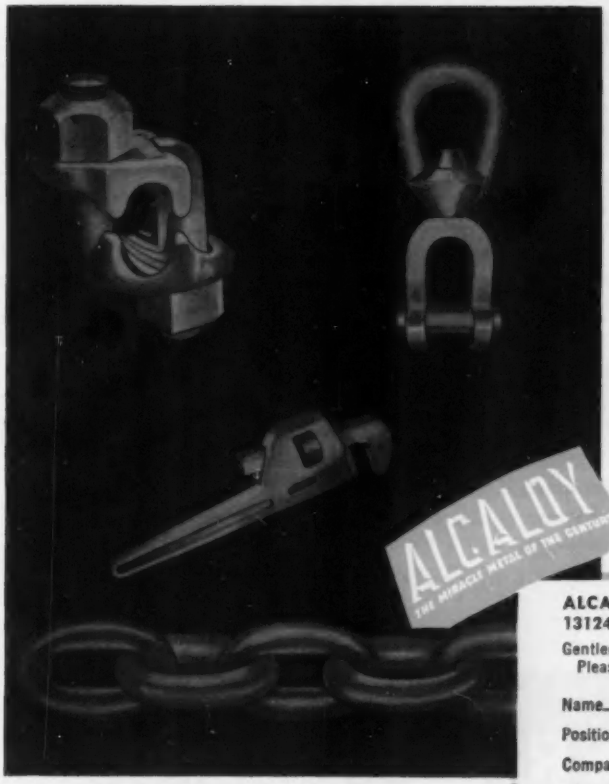

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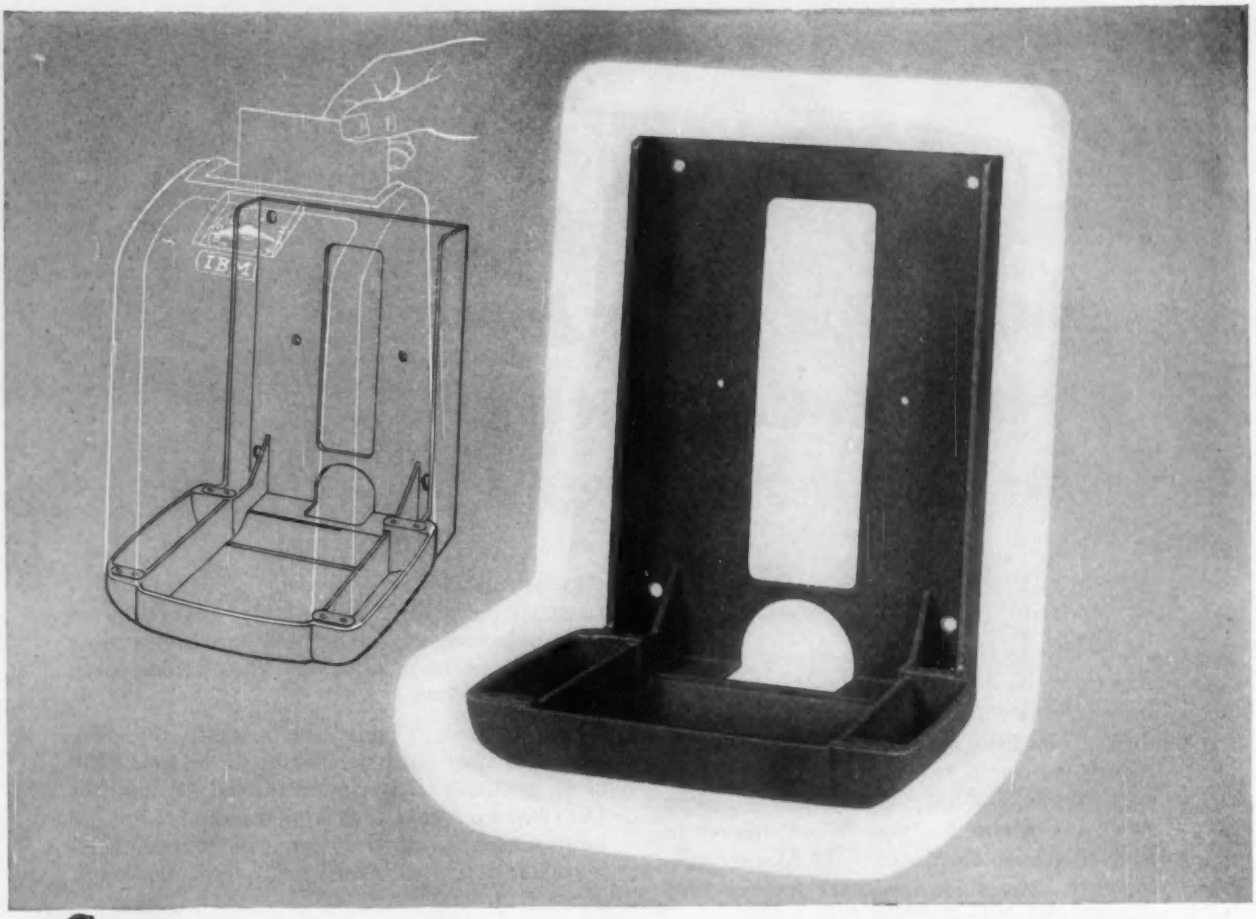

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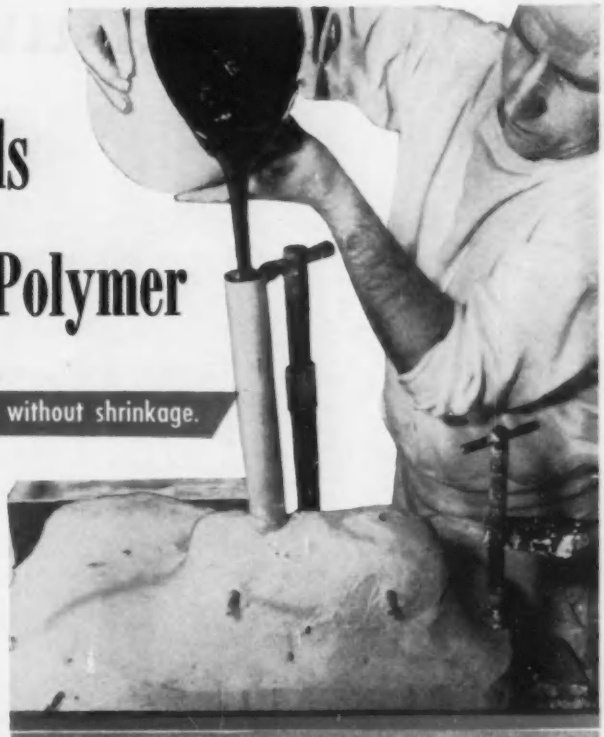

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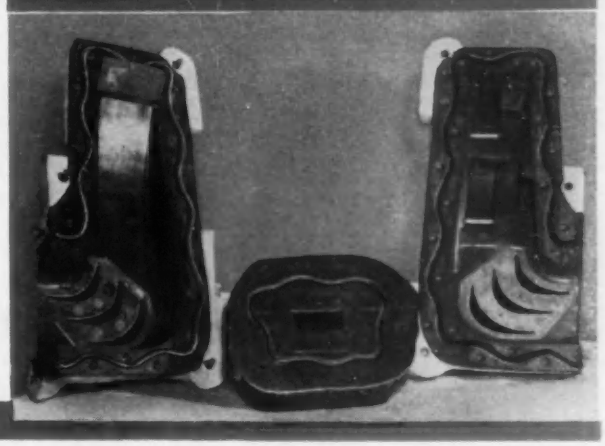

The cold casting compound illustrated is made by the Perma-Flex® Mold Company, Columbus 9, Ohio, and is based on a "Thiokol" Liquid Polymer. Thiokol Chemical Corporation supplies "Thiokol" Liquid Polymers only as raw materials for further compounding.

With cold casting compounds based on "Thiokol" Liquid Polymers, intricate cavities are filled with a flexible rubber that conforms precisely to all details of the shape in which it is cast. In the illustrated application, one of these cold casting compounds is being used to produce a flexible core box pattern. Heavy production of precise investment plaster molds for aluminum can be obtained with this type of pattern.

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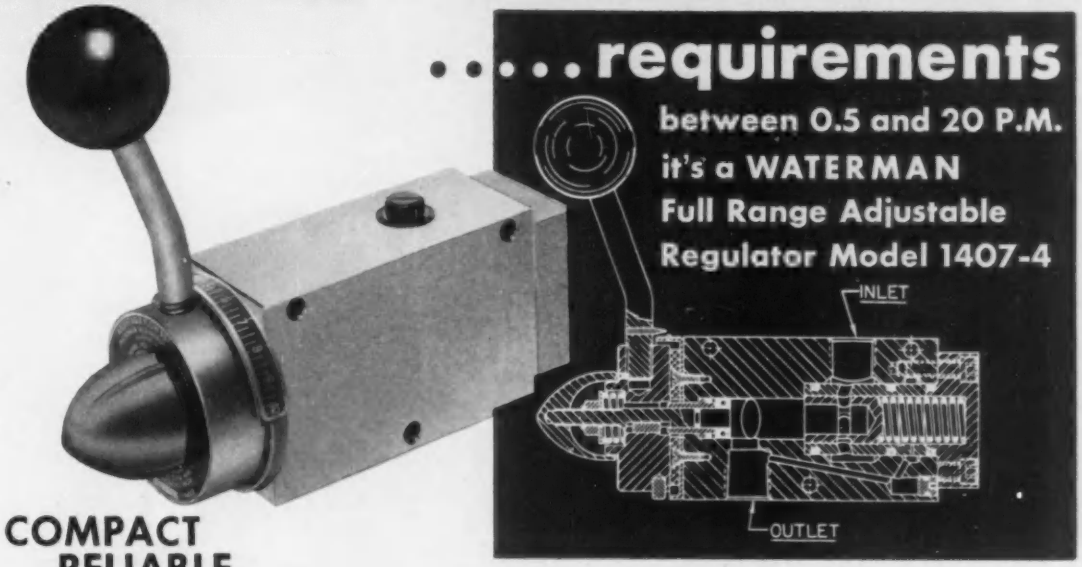

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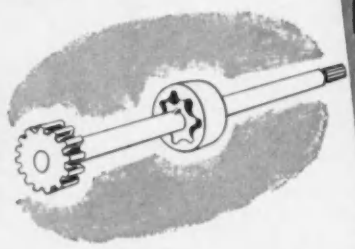

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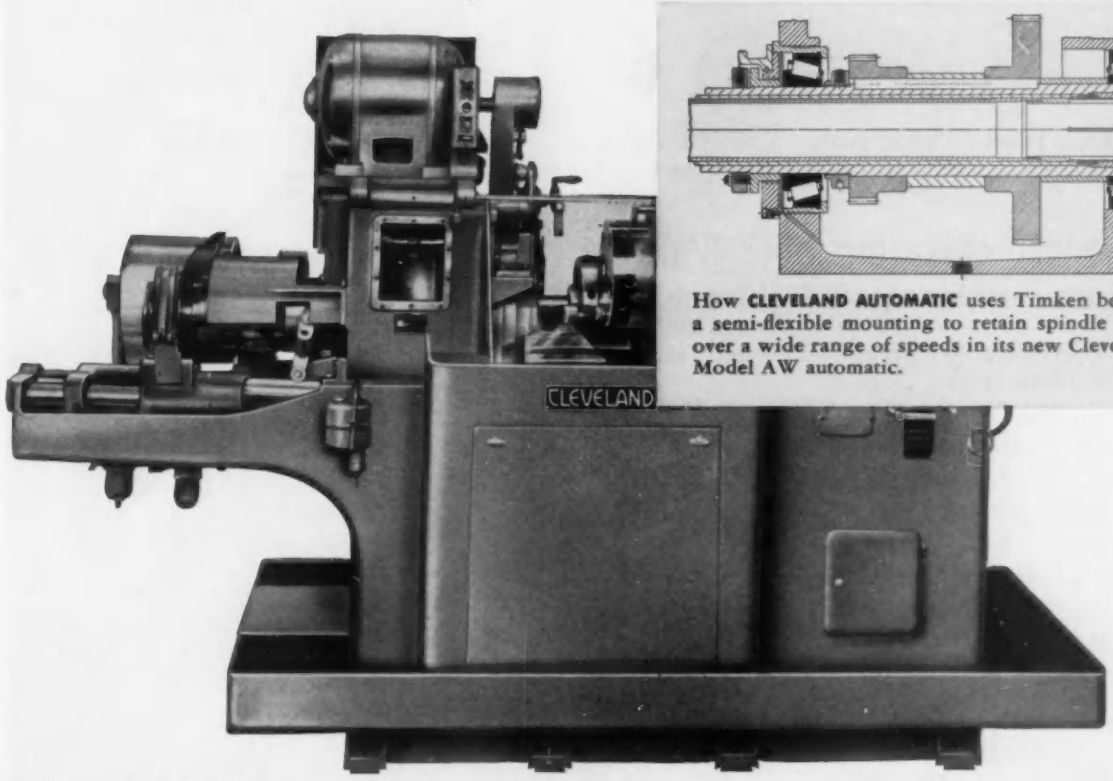
To accommodate its wide range of spindle speeds—40 in all—ranging from 69 to 1920 RPM, and to insure precision at any speed, Cleveland mounts the spindle on Timken® bearings in semi-flexible mounts. This permits any expansion during high speed operation without affecting accuracy.

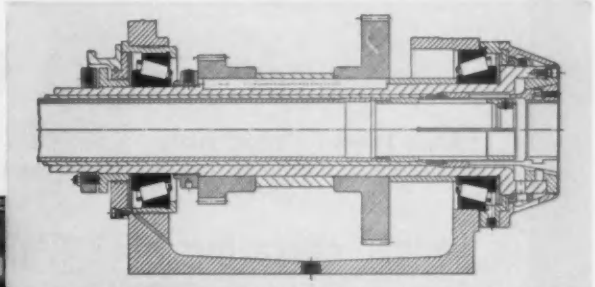
Timken tapered roller bearings hold shafts and spindles in rigid alignment. Line contact between rollers and races provides extra load-carrying capacity. Gears mesh smoothly with minimum wear under even the heaviest loads. Because of their tapered construction, Timken bearings carry radial and thrust loads in any combination.

The true rolling motion and incredibly smooth surface finish of Timken bearings practically eliminate friction. Shafts and housings are held concentric, making closures more effective.

Be sure to specify Timken bearings when you build or buy machine tools. They normally last the life of the machine. Look for the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.





How **CLEVELAND AUTOMATIC** uses Timken bearings in a semi-flexible mounting to retain spindle precision over a wide range of speeds in its new Cleveland 2½" Model AW automatic.

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SMOOTH TO MILLIONTHS OF AN INCH

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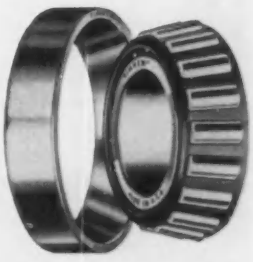

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ▯ AND THRUST ⊣▯⊢ LOADS OR ANY COMBINATION

RIGHT ANGLE
Roller
Ends

RIGHT ANGLE
Bearing
Surfaces

RIGHT ANGLE
Separator
Slots

Longer operating life? Right!
Less maintenance? Right again!

Heavy-duty equipment "rolls right" with Rollways because . . .

. . . solid cylindrical rollers provide the long line-contact required by heavy loads.

. . . precisely made ends, bearing surfaces and retainer slots restrict end-rub, skew and side-shock.

. . . special alloys in the races resist spalling and brinelling.

It all adds up to a bearing that rolls longer, takes less maintenance, prolongs the life of your equipment.

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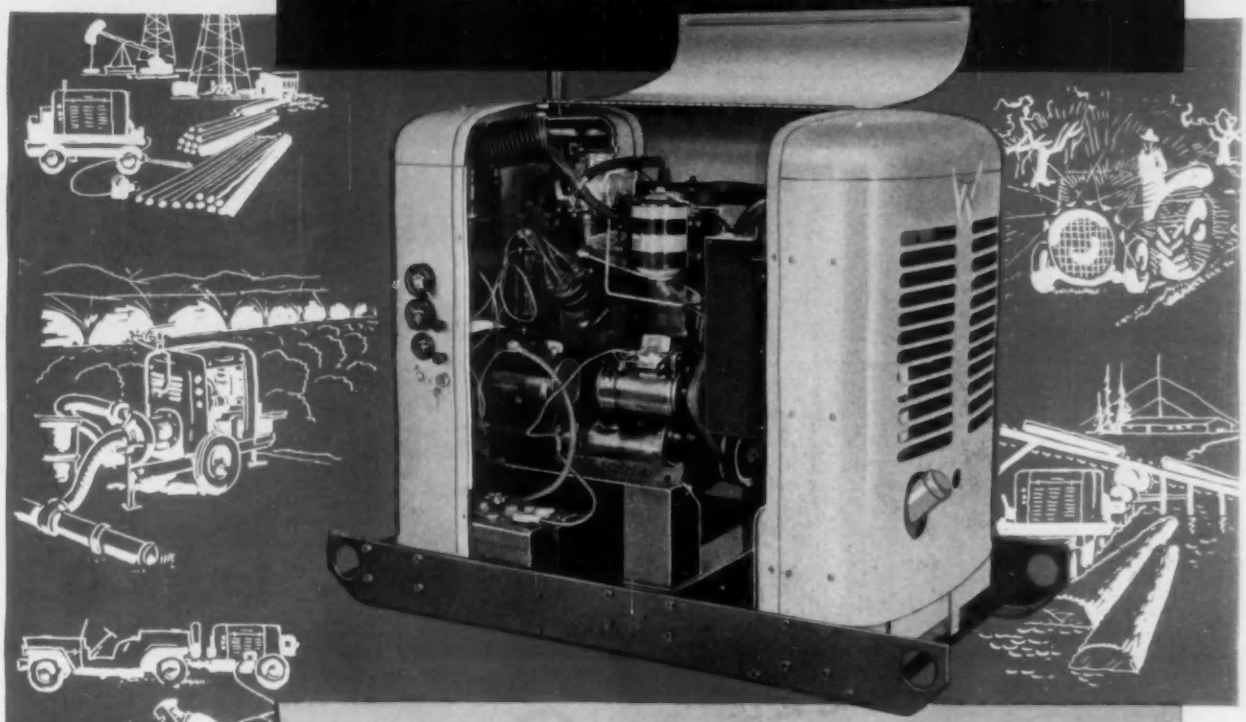
Here's JEEP ENGINE RUGGEDNESS...



Willys POWER GIANT

4 and 6 CYLINDER *POWER UNITS*

From radiator to flywheel, there's long term **ruggedness** in this completely new Willys Power Unit. Each of its four choices of 4 and 6 cylinder POWER GIANT Engines has the famed Jeep "proven-in-action" features. There's positive crankcase ventilation, positive valve rotators, superb engine balance . . . and others . . . to give typical Willys low maintenance and high dependability. All the Unit's working parts are fully accessible through hinged top and removable side panels. Many variations of housing and equipment are available . . . write today for technical literature.

INDUSTRIAL ENGINES AND POWER UNITS

Model	Jeep	Hurricane	Lightning	Giant Hurricane
Cylinder and Head	4 L	4 F	6 L	6 F
Displacement Cu. In.	134.2	134.2	161.0	161.0
Range Max. bhp	22-60	22-70	28-75	28-90
Range of Speed	1200-4000	1200-4000	1200-4000	1200-4200

Complete Specifications
Ask for 4 cyl., 6 cyl. or Power Unit Bulletins.

PROVEN IN ★ ACTION ★

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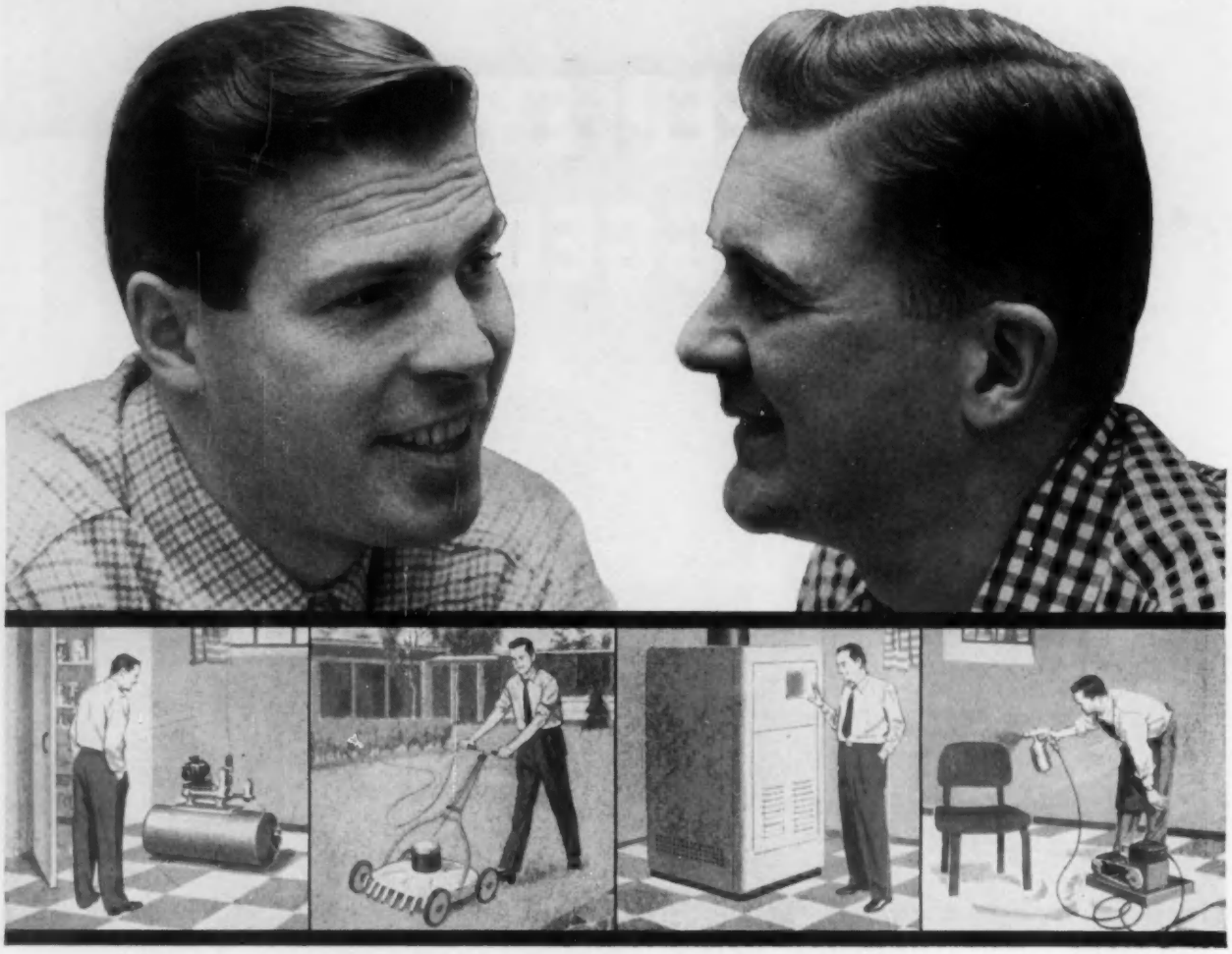
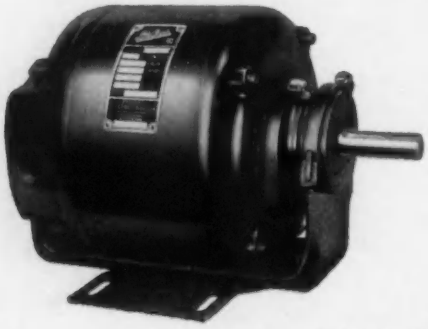
1455 North Cove Blvd. Toledo, Ohio



Satisfied Customers sell new customers...



Look at this man. He's telling a neighbor why he's so pleased with his motor driven appliances. He—a satisfied customer—is just about the best salesman a product can have! One *big* reason for his satisfaction—even though he may not know it—is the Packard Electric motors that power his appliances.

Packard fractional horsepower electric motors have been making satisfied customers for 38 years—because a Packard motor does its job longer, quieter, with less maintenance cost. The appliance maker who standardizes on Packard Electric motors gives his product that extra touch of dependability that builds sales.

product of GM GENERAL MOTORS *General Motors*

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Packard Electric Division, General Motors, Warren, Ohio

Flash butt-welding of mill-rolled sections will save $186,888.00 this year for one jet engine manufacturer

By designing the mill rolled section shown above, instead of using a rectangular bar, 98 lbs. of metal per ring was saved. The cost of fabricating rings was reduced $77.87 per ring.

Are you using machined rings or bands? Rolling and flash butt-welding of special mill-rolled sections may be able to effect similar economies. Write today for complete information. Our Product Development Division will be glad to work with you.

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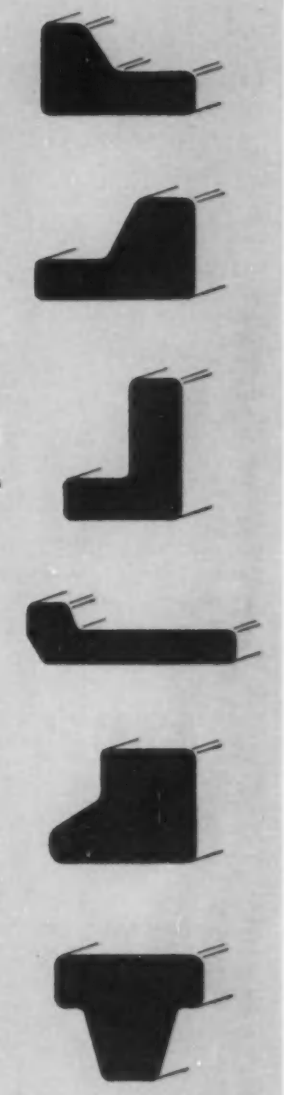
AMERICAN WELDING

WELDING • MACHINING • FABRICATING

TYPICAL STAINLESS MILL ROLLED SECTIONS



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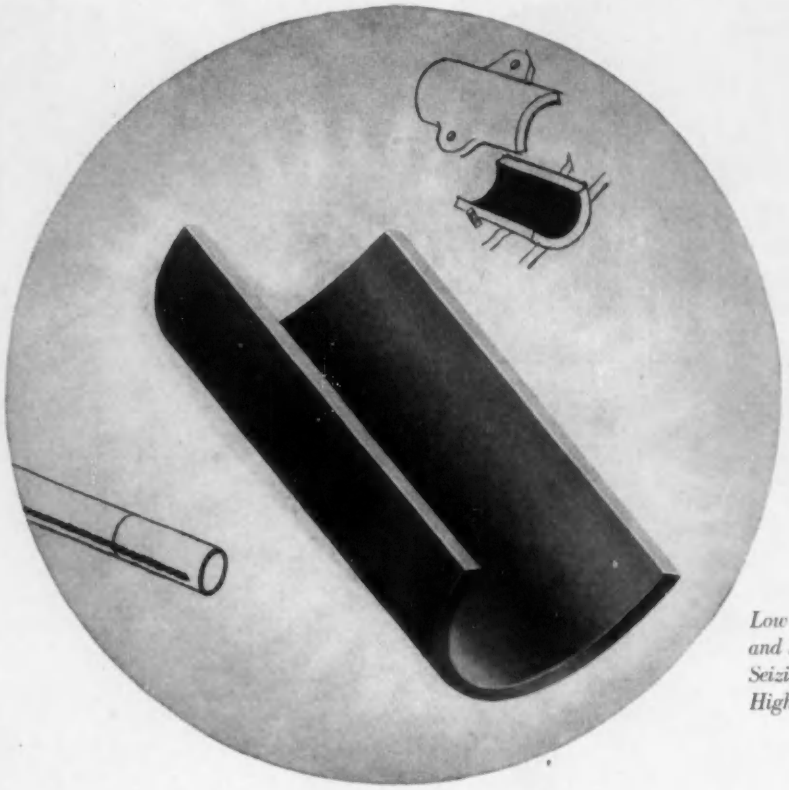

Low Friction Bushings and Sleeves Resist Seizing, Abrasion, High Temperatures

HAYNES STELLITE Bushings and Sleeves

Trade-Mark

...for handling Hot-Abrasive Materials

Bearing parts made of HAYNES STELLITE alloy resist seizing and galling. They are hard and abrasion resistant, and will withstand the pitting effects of many corrosives. They take a high polish and are easy to apply. Use them to reclaim worn shafts or bearing blocks, and to lengthen the life of new equipment.

Operate with Little or No Lubrication

Sleeves made of HAYNES STELLITE alloy can be used in areas where efficient lubrication is impossible. They resist seizing even when lubricants are diluted by gasoline, cleaning fluids, and other liquids that wash out an oil film. They operate at peak efficiency even when lubricants decompose under heat, or are destroyed by abrasive particles.

Tough and Abrasion-Resistant

Bearing parts made of HAYNES STELLITE alloy resist the abrasive effects of wet or dry materials such as fly ash, coke, metal powder, shale, and cement dust. They are hard enough to carry heavy loads, and tough enough to stand up under repeated stress.

Heat and Corrosion Resistant

These bushings and sleeves can be submerged in many acids, alkalies, and molten metals. Temperatures as high as 1500 deg. F. have little effect on their hardness, toughness, and dimensional stability.

For more information write for our 8 page booklet on half bushings and sleeves.

"Haynes" and "Haynes Stellite" are registered trade-marks of Union Carbide and Carbon Corporation.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

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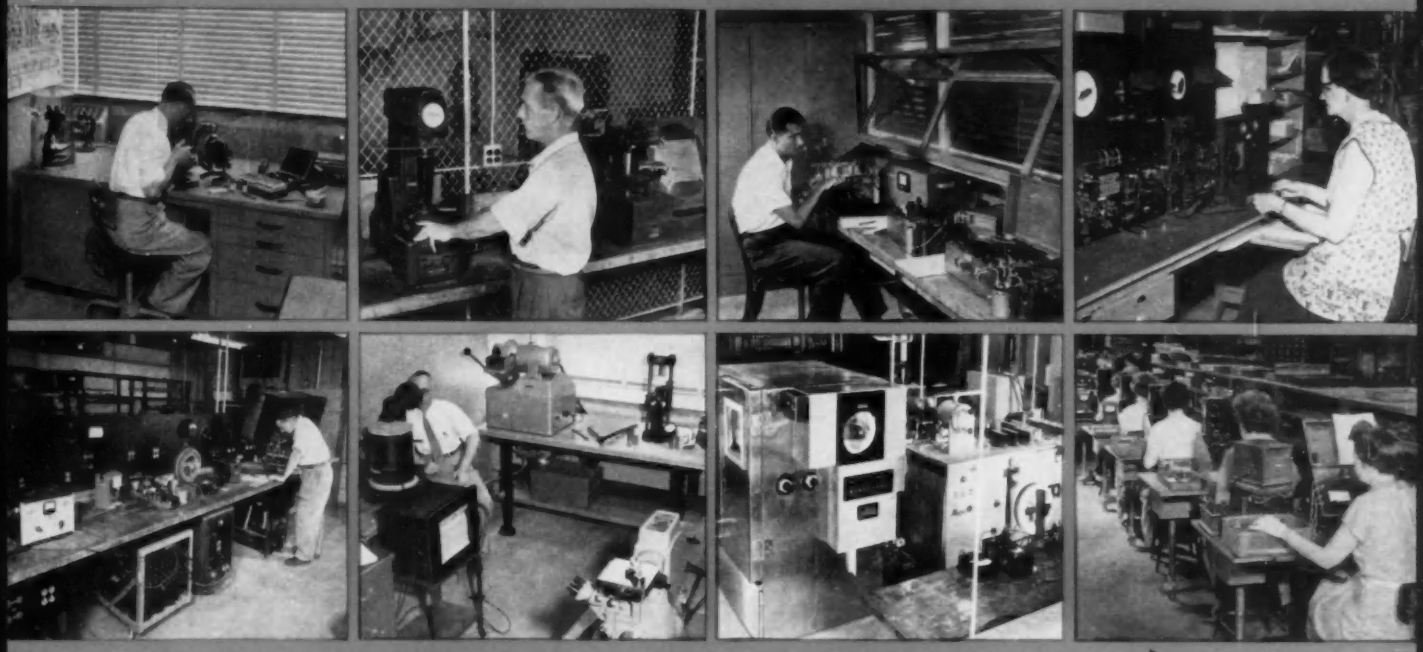
OHMITE® resistor RELIABILITY...

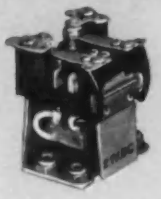


TESTING...

TESTING...

never-ending TESTING!

30th Anniversary
1928-1953



RELIABLE RELAYS, TOO!

When you need fast delivery on relays of highest quality, investigate AMRECON® general-purpose relays. They are available in current ratings up to 25 amp AC or DC (in all std. voltages); in a wide variety of contact arrangements; and with hermetically sealed or dust-protected enclosures.

WRITE FOR CATALOG AND DESCRIPTIVE BULLETIN R-10

AMERICAN RELAY & CONTROLS, Inc.
3653 Howard St., Skokie, Ill.
An OHMITE Subsidiary

You can't afford the risk of failure in your equipment. Insist on components of proven reliability. In the modern Ohmite laboratories, Ohmite resistors are tested and retested under the most grueling conditions so that potential sources of trouble can be detected and eliminated. And, Ohmite is constantly searching for new materials, new processes, and new designs—to build Ohmite products that set new standards of long life and trouble-free performance.

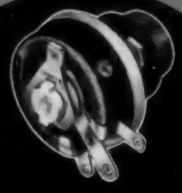
OHMITE®

RHEOSTATS • RESISTORS • TAP SWITCHES

OHMITE MANUFACTURING COMPANY, 3611 Howard Street, Skokie, Illinois (Suburb of Chicago)

WORLD'S LARGEST STOCK

RESISTORS
Fixed and "Dividohm" adjustable wire wound types, 10 to 200 watts. Also composition type.



RHEOSTATS
Ten stock sizes—25 to 1000 watts. All ceramic and metal.

TAP SWITCHES
Rotary type. Five sizes from 10 to 100 amp, with from 2 to 12 taps.

What resistance components do you need in a hurry? From a factory stock of several million resistors, rheostats, and tap switches . . . in 1,859 types, sizes, and values . . . Ohmite can make fast delivery in reasonable quantities to meet your immediate requirements.

Furthermore, by tailoring your specifications to these stock items, you can always get speedy delivery that will help you keep experimental and pilot production operations on a smooth-running schedule.

To assist engineers and purchasing agents in making their selection from this huge stock, Ohmite *Stock Catalog* No. 24 contains complete, up-to-date information on all Ohmite stock items. Resistance values, ratings, specifications, and other helpful information are included.

NEED RELAYS? Get in touch with
American Relay & Controls, Inc.
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30th Anniversary
1926-1956

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Design for... Heat and Corrosion Resistance with *Carpenter* Stainless Tubing

When hollow parts you're designing are going to wind up in hot spots—and must also resist attacks of strong corrosives—that's the time to "call for Carpenter" Stainless Tubing.

Here's a case in point. A manufacturer of gas-fired household incinerators puts long-life resistance to organic acids and scaling at temperatures of 1300-1600°F into the burner tubes by making them out of Carpenter Stainless Tubing. As a result, the part is guaranteed for many years of service life. Slotting, forming and other fabricating operations involved in making the parts are easily performed—production costs held down . . . and Carpenter quality and uniformity make the difference.

There are Carpenter analyses to combat every corrosion condition—defeat even the strongest corrodents—and remain scale-free at high temperatures. What's more, you can be sure of getting the uniform properties, tolerances, finish and quality you need for trouble-free fabrication when you specify Carpenter Stainless Tubing.

It may pay you to discuss your product designs with your nearest Carpenter Tubing Representative or Distributor. A NEW bulletin, "Fabricating and Working Data" is yours for the asking.

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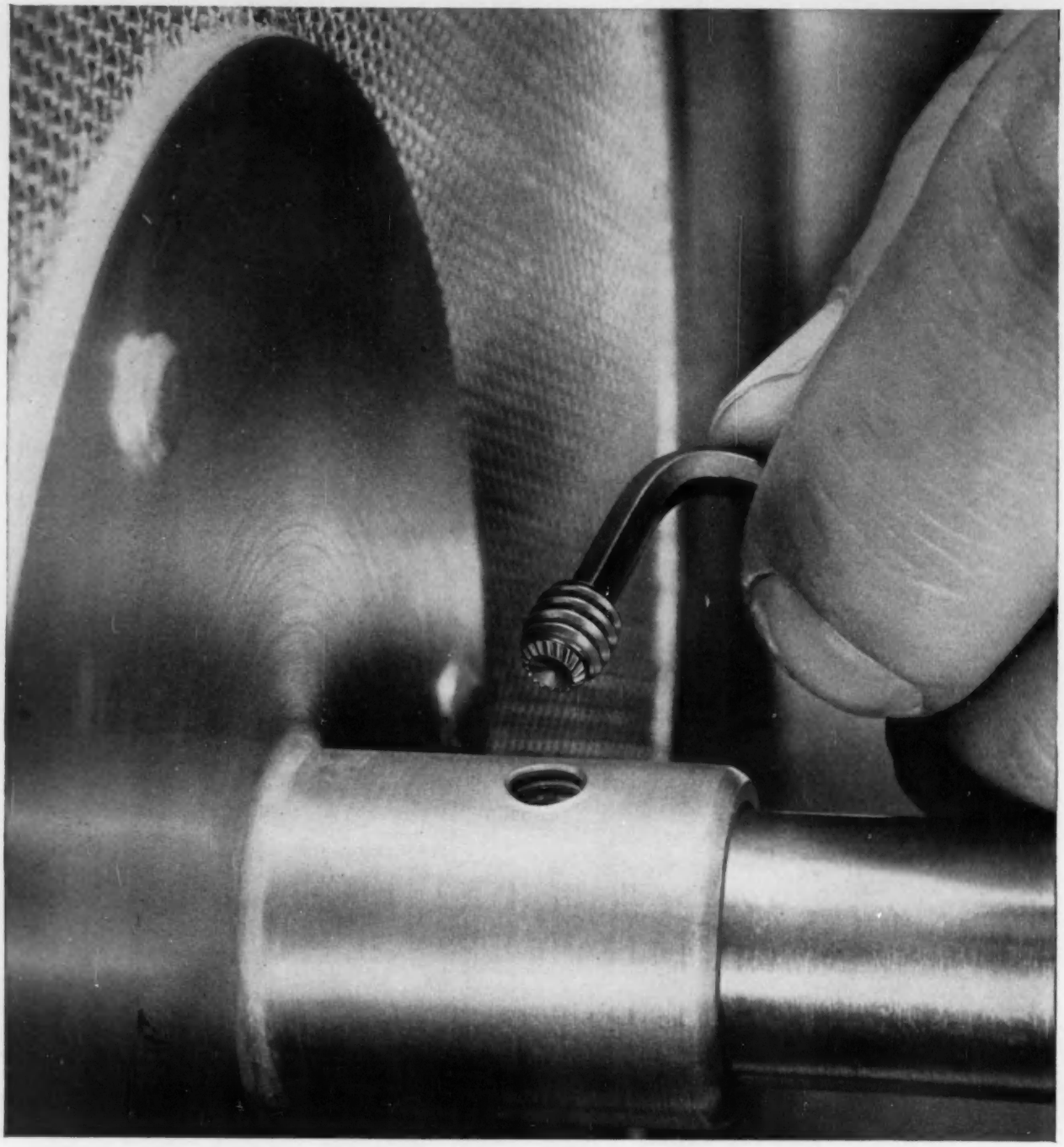
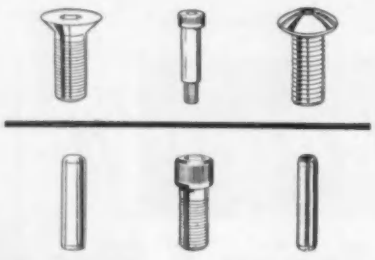
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

Stainless Tubing & Pipe





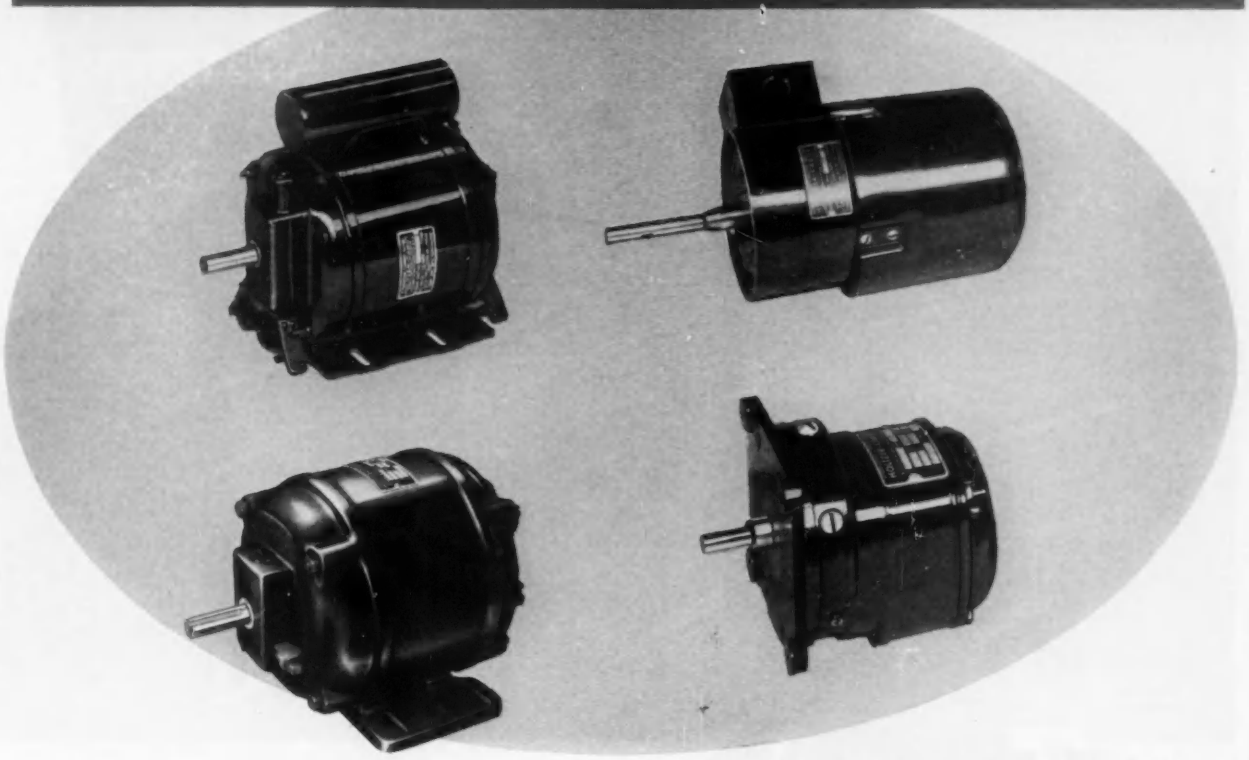
HOW TO KEEP A SET SCREW TIGHT. Tighten it as tight as possible. Keep it in place by preventing it from starting to work loose. With UNBRAKO Self-Locking Socket Set Screws you can do both. They are designed for the highest recommended tightening torques in the industry—as much as 45% higher than those used for ordinary socket set screws. UNBRAKOs have the unique knurled cup point which prevents them from starting to work loose, even in poorly tapped holes. For the complete UNBRAKO story, see your industrial distributor—or write STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

UNBRAKO® SOCKET SCREW DIVISION SPS JENKINTOWN, PENNSYLVANIA

HOLTZER-CABOT

Fractional Horsepower Motors

1/200 to 1 H. P. - 3" to 7" frame diameters - single phase, polyphase, direct current



Holtzer-Cabot fractional horsepower motors are available in an extensive range of electrical types, frame diameters, lengths, mechanical and electrical variations. This wide range permits the selection of the ideal motor for your product. Or, if needed, our highly skilled personnel can develop, promptly and efficiently, special custom-built motors for your specific applications.

The following basic motor designs are available for 60-cycle operation. Most of the a-c designs have d-c companions. Electrical variations include: voltage, frequency, single or polyphase operation. Partial motors, for direct insertion into your product, are also available.

ELECTRICAL TYPES

- SPLIT PHASE
- CAPACITOR
- SYNCHRONOUS
- REPULSION INDUCTION
- SERIES AC OR UNIVERSAL
- DIRECT CURRENT
- POLYPHASE
- MULTI-SPEED
- RAPID REVERSING
- GENERATORS

These types can be combined to provide motor-generator sets, inverters, dynamotors, frequency changers, and countless varieties of electrical apparatus (up to 7" in diameter) which are not normally classed as motors or generators.

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TYPICAL MECHANICAL FEATURES

Ball or sleeve bearings
Special mountings: resilient, laminated steel spring or rubber, flange, face, vertical
Open or totally enclosed
Special shafts — unlimited variations; double shafts to 43" long
Special lubrication for any mounting position or operating condition
Special shapes, e.g. "pancake" type with short axial length
Partial motors

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston 19, Mass.

GENTLEMEN ☐ Please send me complete design information on Holtzer-Cabot fractional horsepower motors.

☐ Please have representative call..... (date)

Name.....

Title.....

Company.....

Street.....

City.....*Zone*...*State*...

NATIONAL PNEUMATIC CO., INC. AND **HOLTZER-CABOT** DIVISIONS

125 Amory St., Boston 19, Mass.
Sales Service Representatives in Principal Cities throughout the World

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GET THIS *Free* 16-PAGE BALL JOINT GUIDE!

This attractively printed 16-page TOUREK Ball Joint Guide-Catalog will be mailed to you without cost or obligation. It contains pictures, diagrams, cross sections, tables, ideas, suggestions and other technical data especially designed to help YOU specify exactly the right Ball Joints for your specific applications. Send for your copy today!

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EXTREME UNIFORM ACCURACY IN
SCREW MACHINE PRODUCTS

STEP UP PRODUCTION WITH *Better* BALL JOINTS

Extreme uniform accuracy in mass-producing Ball Joints has been a specialty of ours for more than 34 years. This UNIFORM precision of every operation in production runs of hundreds or thousands has cut assembly time, improved performance and brought peace of mind to many quality-minded manufacturers from coast-to-coast!

More and more critical buyers "turn to TOUREK" *consistently* for finer quality in Screw Machine Products too.

TOUREK's wide engineering experience and large production facilities can be depended upon implicitly for the kind of service and cooperation you need. Send for the free 16-page Guide pictured above. Or, ask us now for ideas, suggestions and estimates on the next job in which Ball Joints or Screw Machine Products are involved.

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. . UP TO 2-5/8" DIAMETER SINGLE AND MULTIPLE SPINDLE MACHINES . . THREADING • TAPPING • MILLING • DRILLING • GRINDING • POLISHING • PLATING • HEAT TREATING • SILVER SOLDERING •

WORLD'S LARGEST MANUFACTURER OF BALL JOINTS

HOLTZER-CABOT

24 and 25 Size Synchronous and Induction Capacitor Type Motors

Single phase, 2, 3 phase

R-24 MOTOR

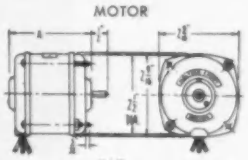
R-25 GEAR MOTOR

THE R-24 size Holtzer-Cabot motor is a reversible, low inertia, 4-pole induction motor designed for application to modern, high-speed industrial process control and instrumentation. It is especially suitable for AC servo application because of its low rotor inertia (¾" rotor diameter). When operated 2 phase, it can be controlled electronically; it can also be operated single phase as a permanent split capacitor motor.

THE R-25 size motor, as designed by Holtzer-Cabot, was the first of its size ever built. It is approximately 2½" in diameter and is available in either induction or synchronous construction with reversible rotation.

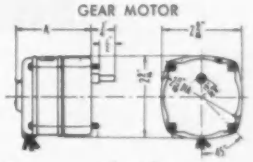
STANDARD DIMENSIONS*

MOTOR



Frame	"A"
2505	2 1/32"
2510	2¾"

GEAR MOTOR



Frame	Gear Case	A
2505	Shallow	2 7/16"
2505	Deep	2 11/16"
2510	Deep	3 5/16"

*APPROXIMATE: See data sheets for exact dimensions

SPEEDS available from ½ to 3600 RPM

TORQUE RATINGS up to 75 ounce inches as standard — higher ratings for special applications

POWER CONSUMPTION — 10 watts (approx.)

Mail coupon today for complete information

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City.....*Zone*....*State*.....

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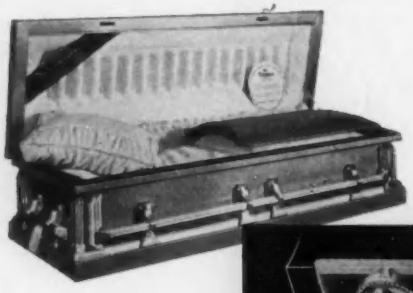
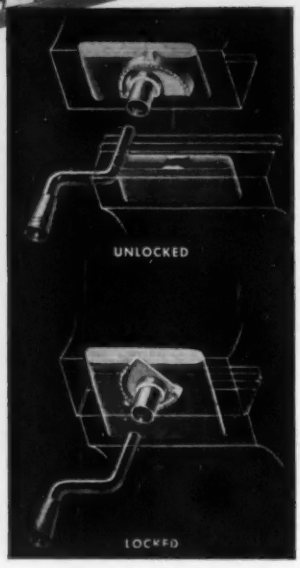
"Nothing can go wrong with Roto-Lock performance"

Says Elgin Metal Casket Company





Roto-Lock operation is simple: Serrated, tapered cam engages latch — draws panels tightly together when turned by crank or other hand tool.

Simmons Roto-Lock Fasteners are used by Elgin Metal Casket Co., of Elgin, Illinois, to give its Permaseal Caskets a perfect hermetic seal against air and water. Drawn down with a pressure of up to 1500 lbs., Roto-Lock guarantees an absolutely tight seal and strength far beyond requirements.

President E. B. Stewart of Elgin says: "Roto-Lock worked out particularly well because of the simplicity of its construction, and the fact that it was a lock already in a housing which could readily be sealed. Functionally the lock is very good since it pulls the lid down with ease and is a quick-operating mechanism. In other words, *the locking and sealing operation can be accomplished quickly and easily in a matter of seconds.* Since the whole locking and sealing mechanism contains only one moving part, *there is nothing that can go wrong with the performance of the lock.* Of course, this is important since mal-function at a funeral service would be a serious matter."

and there's a Roto-Lock application to improve your product

Roto-Lock, which makes butt or right-angle joints quickly, is finding wide application in portable shelters, air freight and cold storage shipping containers, walk-in coolers, demountable furniture and scaffolding. It fastens in any misaligned or semi-open position and recesses completely into panels. *Wherever* demountability is important, there's a Roto-Lock application.

Write today for our 36-page catalog. It's filled with applications of Roto-Lock and Simmons' four other special fasteners engineered to improve products and reduce assembly costs.

SIMMONS FASTENER CORPORATION
1751 N. Broadway, Albany 1, New York

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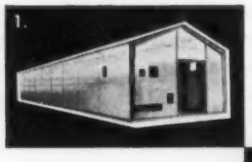
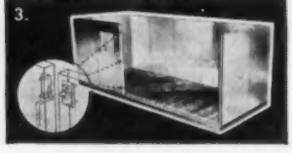
QUICK-LOCK · SPRING-LOCK · ROTO-LOCK · LINK-LOCK · DUAL-LOCK

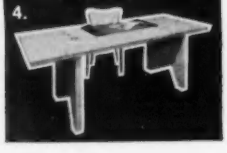
FASTENERS WITH USES UNLIMITED



Some applications of Roto-Lock:

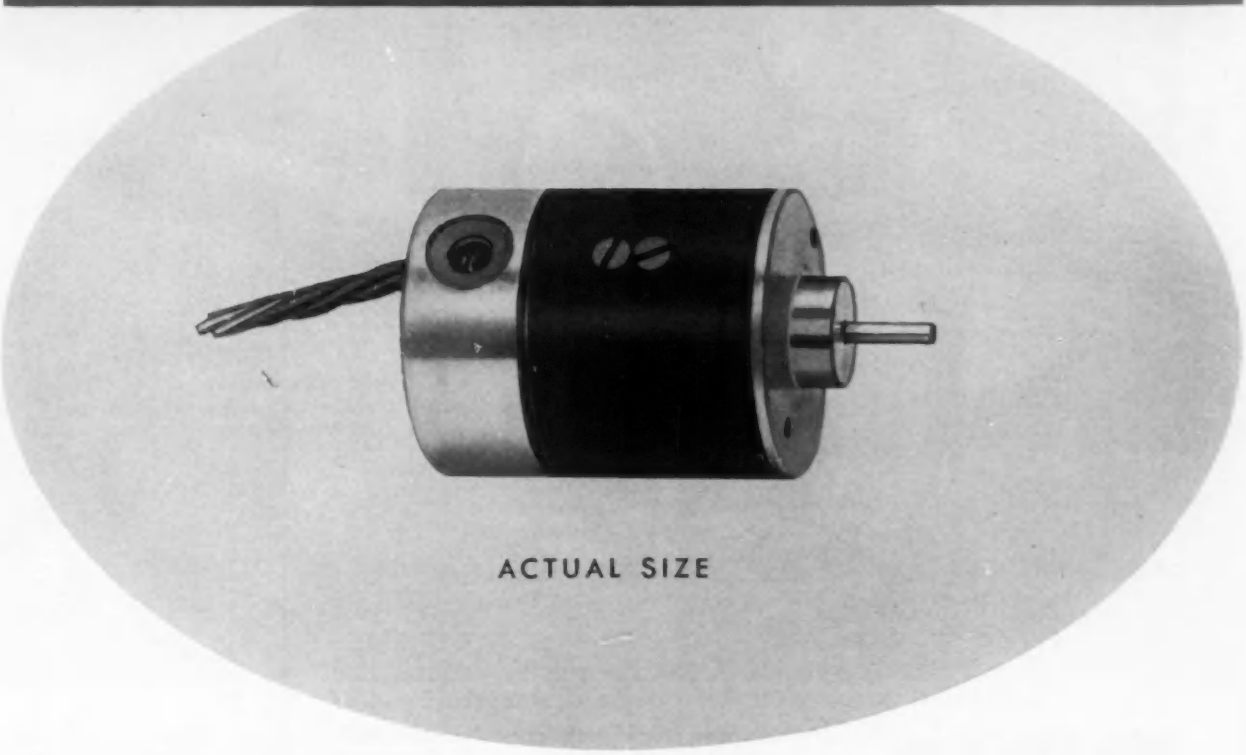
1. Portable Shelter
2. Partition
3. Demountable Refrigerator Unit
4. Demountable Desk





HOLTZER-CABOT

D-C Miniature Servo-Motor



ACTUAL SIZE

This Holtzer-Cabot Servo-Motor gives outstanding performance featuring immediate response to minimum input signal. Designated Type RBDS-0810, it is normally used with field control by two electronic tubes in push-pull — in applications such as gun fire control, computing mechanisms, radar navigational systems and radio tuning.

The armature of this motor is designed for continuous excitation from a 24 to 29 volt D.C. source through a 28 ohm series resistor. The field has two 10,000 ohm sections — one for CW and the other for CCW rotation. Full rated motor output is obtained by 6 m.a. differential (e.g. — 3 m.a. in one section and 9 m.a. in the other). The motor will start at approximately 1 m.a. differential field current.

The Type RBDS-0810 Servo-Motor meets all requirements as to vibration, humidity, fungus resistance and wide temperature range.

SPECIFICATIONS: Rating 0.3 oz. in. — 6500 R.P.M., — .002 H.P.; Diameter 1⅝″; Field Current 6.0 Milliamps: Armature Current 0.8 amp; Duty Cycle: 4 Reversals per minute; Altitude: 50,000 feet; Ambient Temperature: minus 65°C. to plus 72°C.

Mail coupon today for complete information

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Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston 19, Mass.

GENTLEMEN: — Please send me data sheets on the Holtzer-Cabot RBDS-0810 Servo-Motor.

☐ Please have representative call ..... (Date)

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FORD THUNDERBIRD . . .
distinctive new addition to the Ford Motor Company's line of cars

THREE TONS OF THRUST!

. . . and up to one-half inch stroke — enough force to lift *two* cars like the Ford Thunderbird illustrated — is now available in a new, *hydraulically formed* bellows developed by Clifford.

Bellows now handle large forces!

Not many years ago, bellows were commonly used only for handling forces of small magnitude — chiefly in connection with instrument actuation.

But in recent years, advances in hydraulic forming techniques have resulted in bellows that can handle amazingly large forces!

For example, Clifford has developed a bellows four inches in diameter having a pressure rating of 550 psi — which is capable of handling forces of over 6,000 pounds! Other bellows and assemblies of various sizes and materials are available to handle forces of surprising magnitudes that may open up new possibilities in your hydraulic or pneumatic designs.

Can you take advantage of this development?

Flexible, leakproof, metallic bellows assemblies offer distinct advantages in hydraulic systems. They respond almost instantly and require no seals, packing glands, adjustments or periodic "take-up". They form a "frictionless lever system" in transmitting force and changing its magnitude or direction.

Complete assemblies

Clifford is prepared to furnish complete bellows assemblies to your specification . . . bellows and end fittings that will permit easy, economical incorporation of the bellows unit into your design.

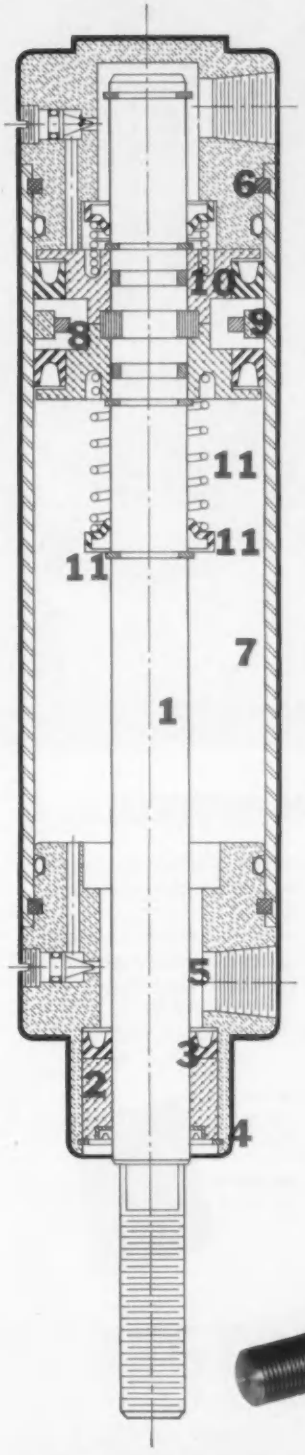
Send for details. Write: Clifford Manufacturing Company, 122 Grove Street, Waltham 54, Massachusetts. *Division of Standard Thomson Corporation.* Sales offices in New York, Detroit, Chicago, Los Angeles and Waltham, Mass.

7.4.69

HYDRON METAL BELLOWS
CLIFFORD MANUFACTURING CO. WALTHAM, MASS.
DIVISION OF STANDARD THOMSON CORP.
HEAT EXCHANGERS

the NEW cylinder with all the most wanted design features

NP Power Drive



1. Extra strong stainless steel piston rod — ground and polished for longer life of rod seal bearing and wiper.
2. Rod wiper and long self-lubricating bronze bearing protect the finish on the piston rod and assure maximum strength.
3. Self-compensating rod packing minimizes friction.
4. Packing and bearing can be easily removed without disassembling cylinder. Both are held in position by a simple retaining ring.
5. Large porting and unrestricted passages permit maximum speeds.
6. 360° pipe location made possible by lock ring assembly.
7. Precision mechanical seamless steel tubing. Rust-proofed by chemical process.
8. Bronze piston bearing to take load from cups, thus providing longer life and sturdier construction.
9. Special lubricating strip protects cylinder wall, piston bearing and cups. Built-in lubrication reservoir adds to life expectancy.
10. Piston cups designed to compensate, automatically, for wear with minimum friction.
11. Unique cushion arrangement consisting of spring and seal can be added to any cylinder at any time. Held in place by lock rings.
12. Interchangeable mountings — foot, flange, pivot, clevis and trunion.
13. Every cylinder operates with air, water or oil without interchanging or adding parts.

No other cylinder offers you so many vital features . . . including: compact, streamlined design; lightweight aluminum alloy and steel construction with *no* sacrifice of strength; sealed in lubrication — eliminates need for external line lubricators; adjustable cushioning (optional).
Ratings: air — 200 psi; water or oil — 500 psi. Bore diameters: 1½", 2¼", 3", 4".

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Sales Service Representatives in Principal Cities throughout the World

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

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Gentlemen: Please send me design information on the *NP* Power Drive Cylinder.....
Include information on NP Power Check feed control ☐ NP Power Trol valves ☐

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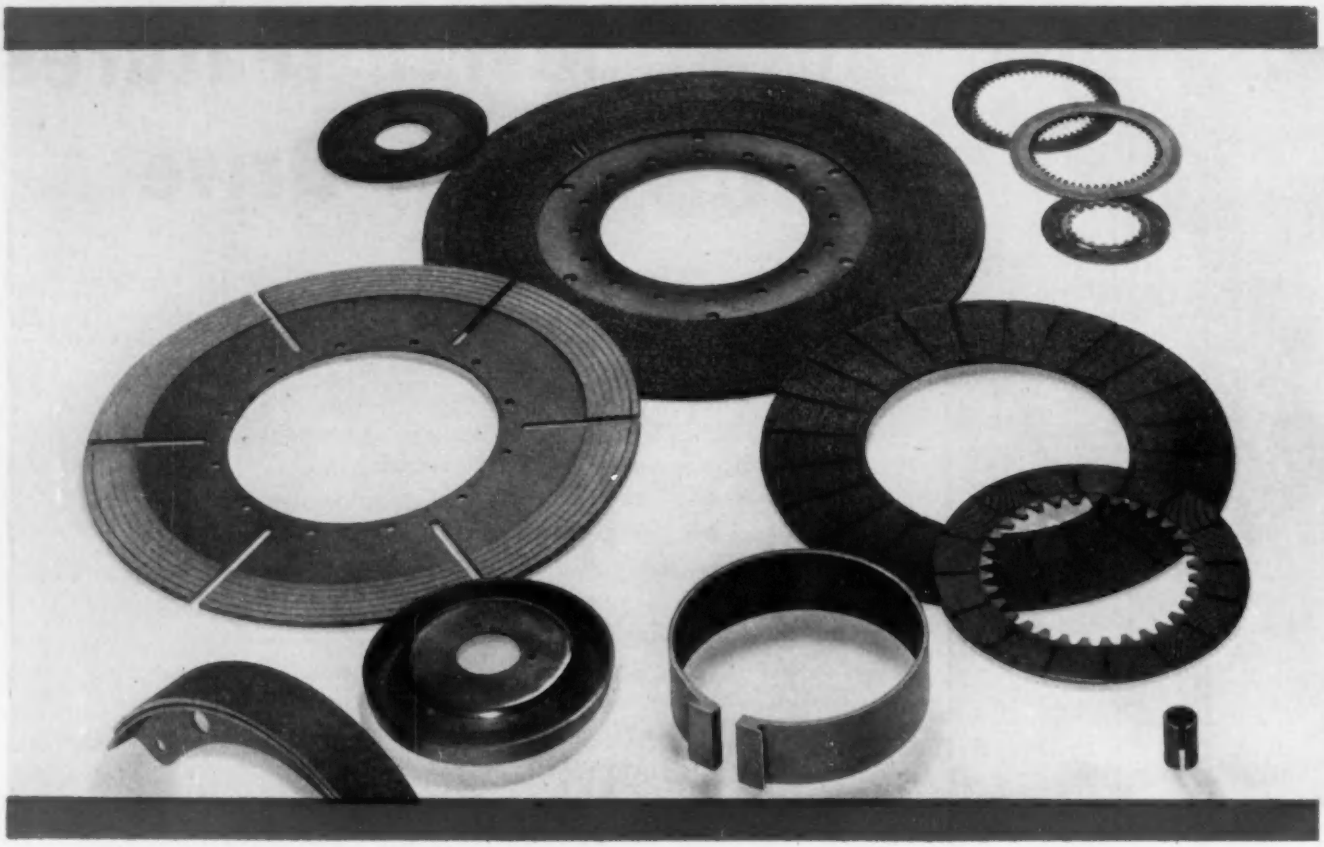

HOW R/M CAN HELP IN BONDING FRICTION MATERIALS

The bonding of friction materials to other mating members is an art. R/M has spent more years than any other company acquiring proficiency in it. Each successive job we've tackled has added to our knowledge of friction materials behavior. And trouble-shooting field trips—hundreds and hundreds of them—have familiarized R/M engineers with countless bonding problems. So the chances are good that if one is confronting you now, R/M has already solved it.

R/M can bond to almost any type material. Steel is most frequently used. But R/M can also bond to aluminum, phosphor bronze, and fibrous materials.

Unlike other manufacturers, R/M works with *all* kinds of friction materials—offers you the widest range in the industry. Consequently you can be sure of completely unbiased advice when you consult an R/M engineer.

If you feel that friction-parts performance could be improved in your equipment, contact Raybestos-Manhattan now. All the depth and breadth of R/M experience—the complete facilities of R/M's seven great plants with their research and testing laboratories—is as near as your telephone.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

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FOR HELP IN SOLVING YOUR PROBLEMS

R/M SUPER-POWER V-BELTS

With R/M Super-Power V-Belts you obtain up to 40% greater horsepower capacity over the same number of regular V-belts. You can save space, as fewer belts are required. In addition, there is virtually no stretch and practically no matching problem. Made with new high strength synthetic cords. Straight sidewalls provide more grip, less slip, longer life. R/M Super-Power V-Belts are also oil-proof, non-spark, and heat-resistant. Bulletin 6628 contains details. Of course, Condor V-Belts continue to be the standard for regular service.

For booklet shown, or other data, write, phone or wire:

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If you have a packing problem, don't hesitate to call on R/M's specialized packing engineering service. R/M has the right type of engineered packing or gasket sheet, no matter what you are sealing: air, gas, water, steam, oil, solvents, foods or hydraulic fluids. Consult R/M also if your requirements call for asbestos textiles or "TEFLON" products. Take full advantage of R/M's many years of experience in all of these fields. Write for booklet on packings, gaskets and "TEFLON" products.

**Du Pont's trade-mark for its tetrafluoroethylene resin*

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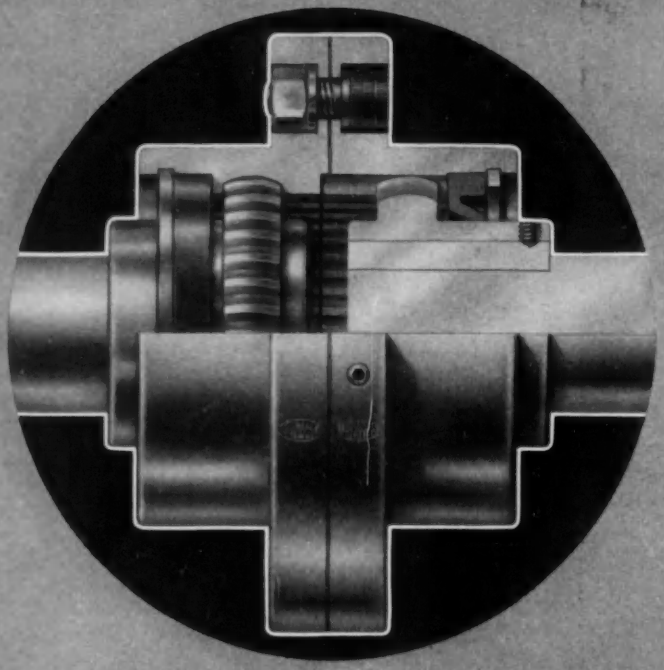
A BETTER GEAR COUPLING

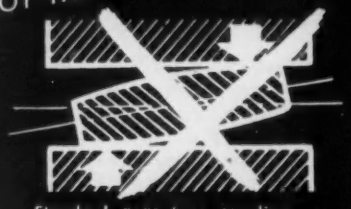
...with teeth cut on a true ARC



SPHEREFLEX

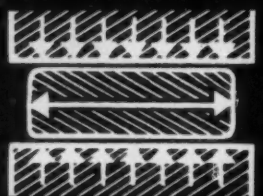
- UP TO 7° ANGULAR MISALIGNMENT
- FULL FACE TOOTH CONTACT ALWAYS
- CONSTANT ANGULAR VELOCITY

NOT THIS



Standard gear type coupling—note excessive backlash and stress concentration when coupling is flexed.

THIS



"SPHEREFLEX"... teeth do not depend on backlash—teeth mesh snugly together, tolerances are reduced to absolute minimum.

The new and different "SPHEREFLEX" Coupling has been exhaustively tested in a wide variety of severe applications—and in every instance has proved itself a superior coupling. "SPHEREFLEX" Couplings are now available from stock at competitive price levels with conventional couplings.

The "SPHEREFLEX" is different and better, because the male teeth are cut on a "true spherical arc", while the internal teeth are cut with a straight root—permitting the curved tooth to always maintain a full line of contact with internal tooth even when the coupling is flexed. . . . Also this feature eliminates the usual dependency for flexibility upon excessive backlash between coupling teeth, point contact or springs. . . . In fact, size for size, the "SPHEREFLEX" Coupling will withstand higher horsepower and greater misalignment than any other comparable coupling. Standard "SPHEREFLEX" Couplings will compensate for angular misalignment up to 3½° plus or minus on each coupling half, or a total of 7°. Special "SPHEREFLEX" Couplings are available for 14° misalignment. Write for new Catalog C-540.

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ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA.
Virginia Gear & Machine Corp., Lynchburg, Va.

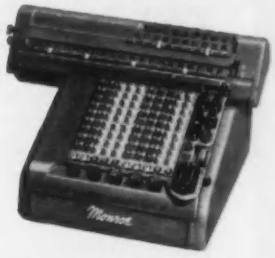
Industrial Gears & Speed Reducers

LimiTorque Valve Controls

established 1892

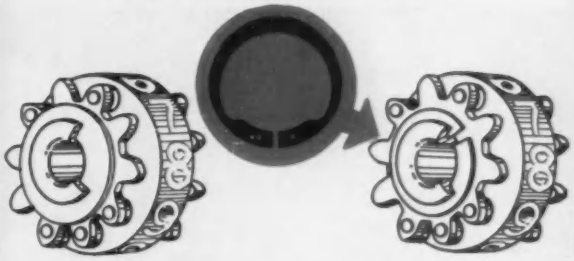
Waldes Truarc rings replace old-fashioned fasteners . . . save assembly time...end scrap loss...increase operating efficiency

This is the Monroe Calculator



...precision-engineered business machine made even more efficient, and less costly to manufacture through the use of Waldes Truarc Retaining Rings.

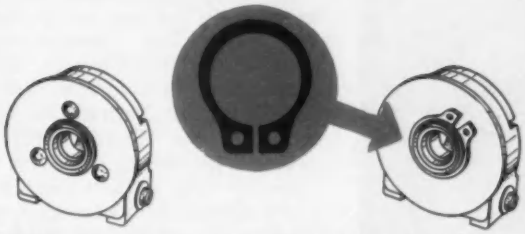
Multiplier Dial Assembly



Old Way. One-piece assembly was spun together. Spinning operation was costly, resulted in high scrap loss.

Truarc Way. Two-piece assembly is held together by one Truarc Ring (series 5108). Rejects: practically zero.

Electric Motor Governor



Old Way. Collector Disc assembly was formerly riveted, requiring skilled labor. Riveted Collector Disc could not be removed in the field.

Truarc Way. Truarc Ring (series 5100) replaces rivets, saves labor, material...improves Collector action. Collector Disc is easily replaced.

Intermediate Gear Shaft

Old Way. Washer riveted on end of assembly for zoning control. Costly, troublesome, hard to obtain critical zoning required.

Truarc Way. Truarc E-Ring (series 5133) cuts assembly time, virtually eliminates rejects and final assembly and zoning problems.

Monroe Calculating Machine Company, Orange, N. J. uses various types and sizes of Waldes Truarc Retaining Rings. Use of Truarc has helped eliminate scrap losses, saved on material and labor, and resulted in increased operating and servicing efficiency of the product. Monroe plans to use Truarc Rings for every possible fastening operation on their entire line!

You, too, can save money with Truarc Rings. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better, more economical job. Waldes Truarc Rings are precision-engineered...quick and easy to assemble and disassemble.

Find out what Waldes Truarc Retaining Rings can do for you. Send your blueprints to Waldes Truarc Engineers for individual attention, without obligation.

SEND FOR NEW CATALOG

WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,948; 2,410,052; 2,420,921; 2,420,341; 2,439,785; 2,441,846; 2,455,165; 2,483,380; 2,483,383; 2,487,602; 2,487,603; 2,491,306; 2,509,081 AND OTHER PATENTS PENDING

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

PN027

Waldes Kohinoor, Inc., 47-16 Austel Pl., L. I. C. 1, N.Y.

Please send me the new Waldes Truarc Retaining Ring catalog.

(Please print)

Name .....

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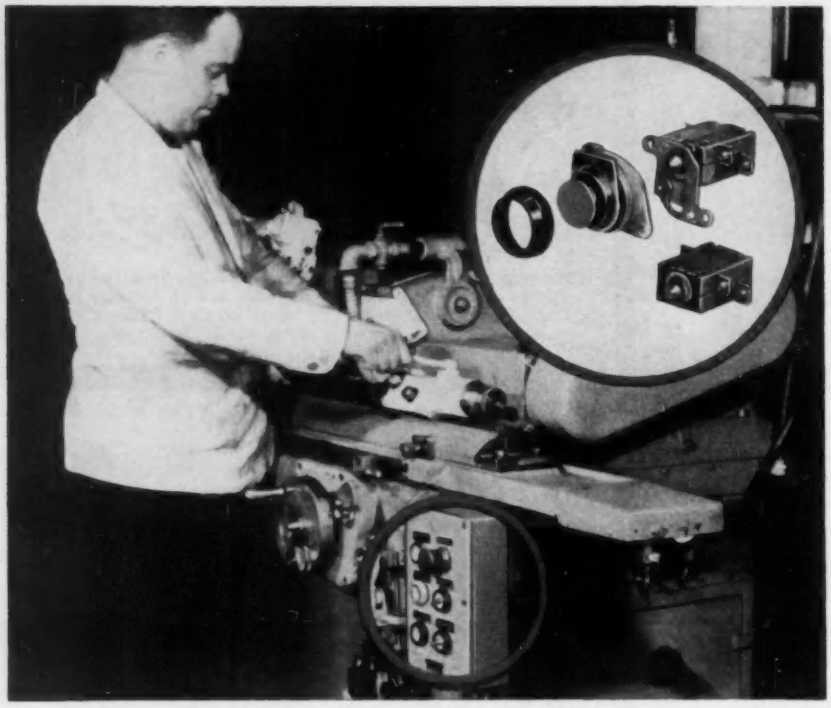
Company .....

Business Address .....

City ..... *Zone* ..... *State* .....

Designer's

G-E oiltight push-button line provides "building block" flexibility



You need to stock only 8 building-block forms—2 operators, 5 color coding rings and 1 contact block—to make 20 combinations. Building-block design adds up to new savings in assembly time, inventory costs and storage space. G-E oiltight push-button units are specifically designed to meet the demands of machinery designers and manufacturers, and include a variety of forms.

Indicating lights include resistor, transformer and full-voltage types, in six brilliant colors. Lights have faceted lenses which protrude from the mounting surface to assure visibility from any angle, yet are triple-sealed with oil-resistant, synthetic rubber.

Unit components, units, enclosures, or complete stations are available in this flexible line. Designed for appearance as well as efficiency, they lend a streamlined look to machines. Color rings stay bright. Both surface-mounted enclosures and flush-mounted plates meet JIC specifications.

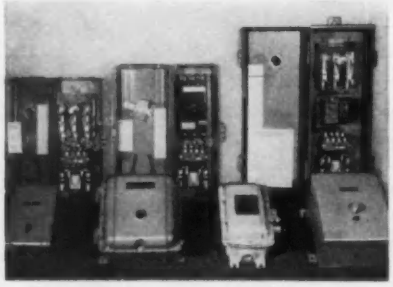
Specify G-E oiltight push buttons wherever hands or gloves may transfer oil or dirt. Ask for Bulletin GEA-5779B.

Quality G-E magnetic starters fit every machine design

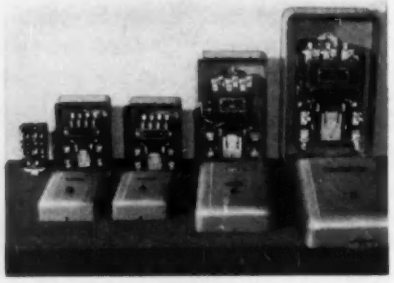
Why does it pay to standardize on G-E motor starters? Manufacturers themselves have given these reasons among many others: "Easiest to install." "Gives our customers the best buy in dependability." "Best long-term assurance we can give customers against motor burnouts."

Starting with the basic contactor unit, you can have accessories, interlocks, control transformers and relays to fit your specific needs. Installation is really simple—G-E starters are front-wired, with hardened panhead screws and plenty of room for easy manipulation. Clamp-type terminals are clearly identified. Knockouts are provided in top, sides and bottoms of enclosures. Screwdriver (all you ever need for wiring) goes straight in to all terminals. "Strongbox" coil construction means a slipping screwdriver won't damage the coil, because the coil is inside a tough, molded plastic case.

Additional benefits for your customers include; the permanent air gap that helps prevent contacts from "sticking in," bi-metallic overload relays that adjust easily for manual or automatic reset, sturdy all-around construction and good looks. For further information on the complete line of General Electric starters, see Bulletin GEA-6198.



THOUSANDS OF VARIATIONS of the above starters are available from the complete line of G-E magnetic motor starters.



Each General Electric starter employs the same basic contactor which has proved superior in severe industrial applications.

GENERAL ELECTRIC

Digest

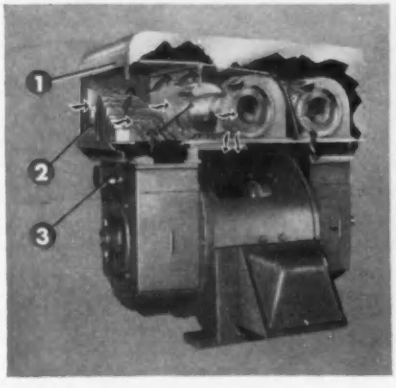
GE MOTOR & CONTROL HIGHLIGHTS

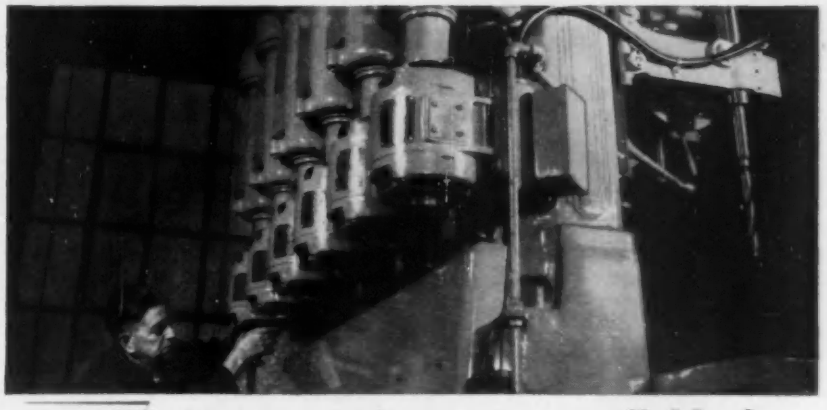
Unit-cooled d-c motors keep out dirt and dust

UNIT-COOLED MOTORS mount at any angle—shown here driving machine boring engine blocks.

If your machines must operate in environments which make open or partially enclosed motors difficult or expensive to maintain, G.E.'s unit-cooled d-c motor is an ideal solution. It is completely self-contained, with no external duct work or air filters to install.

The motor has two air flow systems: external (black arrows in cutaway photo below), and internal (red arrows). The compact, top-mounted cooling unit (1) is within the over-all dimensions of the main motor. Self-cleaning vertical plates (2) are smooth and need little maintenance. Two blowers (3) operating the double ventilation system are powered by separate motors. Available: standard ratings from 15 to 200 hp, in constant or adjustable-speed types. Bulletin GEA-6091 gives complete information.





TRI 55 CLAD motors now available in quantity thru 10 hp—samples to 20 hp

Now you can take advantage of increased availability of new G-E motors in re-rated NEMA frame sizes. When you design-in Tri/Clad '55' motors, your customer will have one of the most modern electrical drives available. This motor line includes standard polyphase and single-phase; NEMA "C" face and "D" flange end shields, brake, gear, shell type, three-quarter, wound-rotor, close-coupled pump motors and specials to your requirements.

Design advantages include weight reduction up to 33% and size up to 40% in some ratings. Note compact, modern appearance of Tri/Clad '55' motors being installed on radial drilling machine, above. Bulletin GEA-6200.

Smaller, more compact fhp motors mount easier

These G-E fractional-horsepower motors free you from previous design limitations, give your machines greater salability. Lighter weight lowers shipping and handling costs. Smaller size means space saved on driven machines, better use of valuable warehouse space. Improved appearance adds to your product's sales appeal. And all-angle operation means this standard, general-purpose motor can often replace costly specials. On the assembly line they're much easier to install, which means additional savings. For full information check Bulletin GEA-5567.

General Electric Co., Apparatus Sales Division, Sec. A668-120, Schenectady, N. Y.

Please send me the following bulletins:

√ for reference × for immediate project

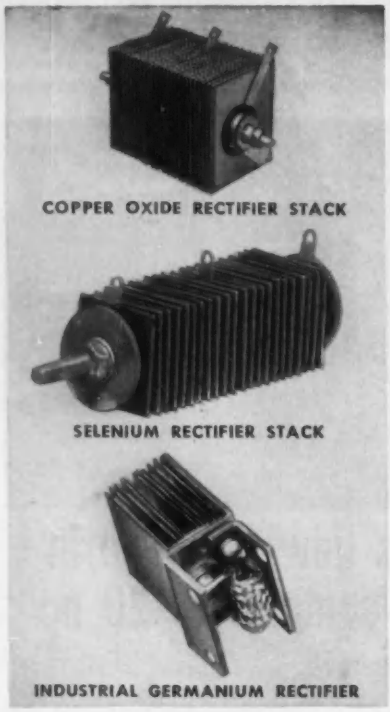
- ☐ GEA-6198 Magnetic motor starters
- ☐ GEA-5779B Oiltight push-button units
- ☐ GEA-6091A Unit-cooled d-c motors
- ☐ GEA-5567 Fractional-hp motor
- ☐ GEA-6200 Tri/Clad '55' motors

CONSULT YOUR SWEET'S PRODUCT DESIGN FILE. You'll find everything electric for machinery manufacturers in the General Electric Section.

NAME ..... COMPANY .....

CITY ..... STATE .....

TURN PAGE FOR MORE G-E PRODUCT HIGHLIGHTS



G-E metallic rectifiers answer industry's growing d-c power needs

General Electric offers designers a complete line of copper-oxide, selenium, and germanium rectifiers to exactly meet specific d-c power requirements.

General Electric copper-oxide rectifiers are able to withstand momentary voltage or current overloads and have the longest life and highest efficiency of all rectifiers at six volts or under. General Electric selenium rectifiers, with their lower forward voltage drop and higher reverse resistance, have proved a very satisfactory source of direct-current power for magnetic clutches and brakes on machine tools. A new 45-volt selenium cell for industrial use provides 40,000 hours of life at 35 C ambient, with no derating at temperatures as high as 120 C. Economical, efficient germanium rectifiers have the best regulation of any metallic rectifier, in addition to the highest output voltage per cell, best current output, and lightest weight per watt output.

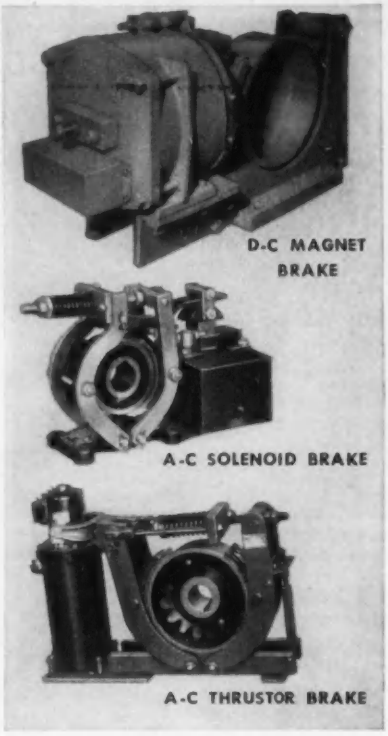
For information on characteristics and application, see Bulletins GEA-5699A (copper-oxide), GET-2350 (selenium), and GEA-5773 (germanium).

G-E a-c and d-c brakes install and adjust easily, give positive stops in varied machine applications

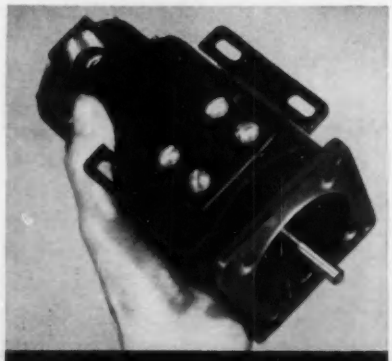
For every braking need, G.E. can provide brakes with all the features that mean quick, easy adjustment and reliable operation. For instance, G-E d-c magnet brakes require only a wrench to make the one simple adjustment to compensate for lining wear. In actual on-the-job tests, the two-shoe, single magnet brake has established high standards of performance in applications where continuity of service and low operating costs are of first importance. Design research was based on industry requirements and standards established by AISE.

G-E a-c brakes are spring-set, two-shoe holding brakes, electrically released by a solenoid in the smaller sizes and a thrustor in larger ratings. Three easily made adjustments control torque, wear, and clearance. They give smooth positive braking in either direction, and their long lining life and wheel life reduce maintenance costs. Both solenoid and thrustor types are available in open, dripproof, or watertight construction.

For further information, check coupon for Bulletin GEA-6214 (d-c brake) and GEA-1518B (a-c brakes).



G.E. announces new, smaller, low-cost tachometer generator



NEW D-C TACHOMETER GENERATOR
TWO MODELS AVAILABLE

50 volts d-c/1000 rpm	100 volts d-c/1000 rpm
0–500 rpm min.	0–500 rpm min.
0–5000 rpm max.	0–2500 rpm max.
Accuracy of ±1% of full scale	Accuracy of ±1% of full scale

Many speed-measurement and control problems in machine design can be answered at low cost with the newest in General Electric's line of d-c tachometer generators. It occupies a minimum of space and can be flange- or foot-mounted, installed horizontally or vertically. This high versatility allows the equipment to be direct coupled, geared, or belt driven, as needed. It is tapped for ½-inch conduit connections.

Two different models are available. The high output voltage of 100 volts per 1000 rpm is ideal for use as a pilot exciter on many control applications and for speed indication. A 50-volt model is also available for speeds up to 5000 rpm.

Whatever your voltage, speed, accuracy, or cost consideration, G.E. has the combination of tachometer generator and instrument to meet your requirements. Write for Bulletin GEC-1258.

GENERAL ELECTRIC

Designer's Digest

PRODUCT HIGHLIGHTS

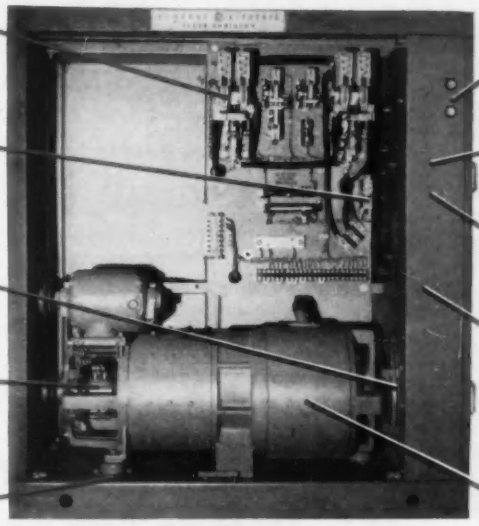
Full capacity d-c magnetic blowout contactors lengthen life of the contact tip.

Complete protection of d-c drive motor and motor-generator by a-c and d-c overload relays.

Shaft mounted fan keeps cabinet pressurized—helps keep dirt out.

Large openings in end shield allow easy inspection of brushes and commutator.

Self-supporting m-g set specially mounted to help prevent vibration.



Simple, start-stop button.

A-c undervoltage protection. Protection of a-c equipment by a-c overload relays.

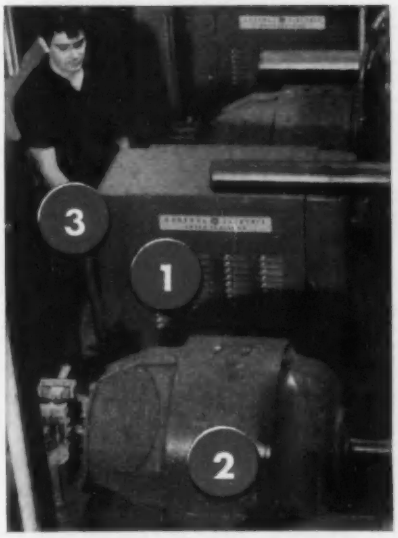
A-c short circuit protection.

A-c control in isolated compartment.

Dependable, powerful motor-generator set matches overload capacity of the d-c drive motor.

Speed Variator power unit.

For custom-engineered adjustable speed specify packaged G-E speed variators



BASIC SPEED VARIATOR consists of: **(1)** the power unit, designed to save space, **(2)** the d-c drive motor and **(3)** the operator's controls.

Before a G-E speed variator leaves the factory, it is pre-engineered, assembled, packaged and completely tested according to *your* specifications. This adjustable-voltage d-c drive means savings in lower installation cost and more efficient production. Simply set components in place—motor, power unit, control—and connect the power.

Speed variators are ideal for lathes, grinders, milling machines, broaches, slotters, boring mills, testing stands, conveyor systems—any machine requiring adjustable speed drives. Providing compensated speed regulation throughout load changes, the basic model covers a wide speed range. The power unit and operator's control can be located as near the driven machines as necessary. Control and regulator "building blocks," added to the basic unit, give even more versatile and accurate speed control, to fit your specific requirements. Bulletin GEA-6127.

General Electric Co., Apparatus Sales Division, Sec. A668-121, Schenectady, N. Y.

Please send me the following bulletins; √ for reference × for immediate project

☐ GEA-6127 Speed Variators
☐ GEA-1518 A-C Brakes
☐ GEA-6214 D-C Brakes
☐ GEC-1258 D-C Tachometer Generators
☐ GEA-5699A Copper Oxide Rectifiers
☐ GET-2350 Selenium Rectifiers
☐ GEA-5773 Germanium Rectifiers

CONSULT YOUR SWEET'S PRODUCT DESIGN FILE. You'll find everything electric for machinery manufacturers in the General Electric Section.

NAME..... COMPANY.....

CITY..... STATE.....

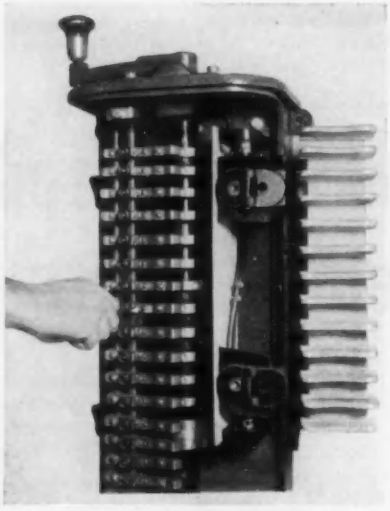
TURN PAGE FOR INDUSTRY CONTROL HIGHLIGHTS

General Electric drum switches offer you simplified installation and maintenance

FAST, EASY INSTALLATION and simplified maintenance are part of G.E.'s full line of drum switches for d-c motors and a-c applications of motor control. The conduit box is provided with knockouts in the bottom, back, and sides so that conduit connections can be made to suit any installation conditions.

EASILY REMOVABLE DRUM SWITCH FRONT COVERS (and back covers on larger units) provide plenty of elbow room for wiring and for adjustments. Installation and maintenance time is substantially reduced because of complete and free access to working parts.

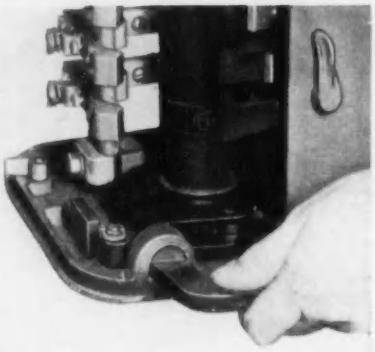
SIMPLE FINGER ADJUSTMENT is accomplished readily with only a screw driver as shown below.



CONTACT LIFE IS DOUBLED because the element is reversible. When the contact surface shows excessive wear merely reverse, and use the opposite side. This is easily accomplished by the removal of but one screw. Segments are easily replaceable and can often be turned end for end to provide even longer life.

PAWL SPRING ADJUSTMENT is simplified by its accessibility from the FRONT of the controller. Adjustments are made by turning a slotted screw as shown in the photograph (right). The arc chute assembly is conveniently hinged for complete access to the pawl spring as well as other internal parts of the switch.

OPERATING MECHANISM CAN BE POSITIONED in increments of 90° by relocating the stop piece on the main shaft. The standard horizontal handle is completely and simply interchangeable for rope wheel, vertical handle, or switchboard mechanism. This ease of interchangeability exists for all operating mechanisms and between various sizes. For additional information on drum switches see coupon on next page.



Complete terminal board accessibility with G-E rotating-cam-type limit switches

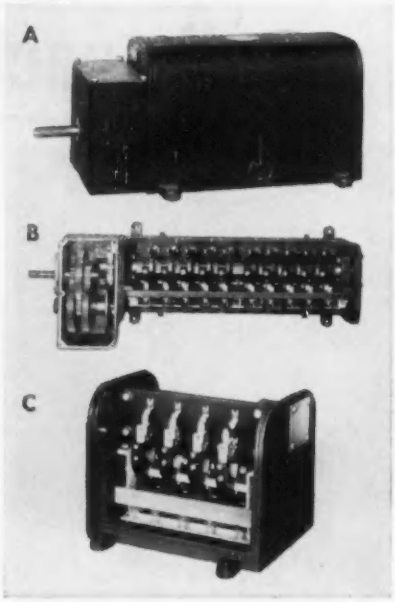
General Electric rotating-cam-type limit switches are built ***without shunts or drum-type segments*** allowing complete access to the terminal board. Adaptable for continuous rotation in either clockwise or counterclockwise direction and for reversing service they are available for two-, four-, six-, and ten-circuit installations.

BUILT FOR RUGGED DEPENDABILITY, G-E rotating-cam-type limit switches are made with cast-iron frames and sheet metal covers. The contacts are double-break type with silver tips. Better interrupting ability and precise operation are achieved by "snap" action. For additional information on G-E limit switches see coupon on opposite page.

A. IC9441-LS429 Geared Limit Switch with self-contained gear-reducing unit mounted on frame.

B. IC9441-LS437 rotating-cam-type limit switch with contacts provided for ten circuits.

C. IC9441-LS464 rotating-cam-type limit switch designed for four circuits.



GENERAL ELECTRIC

Designer's Digest

INDUSTRY CONTROL

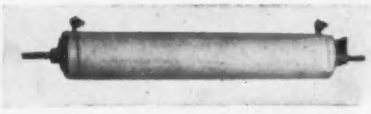
Complete line of G-E resistors gives you maximum application flexibility

DESIGNED WITH A WIDE RANGE of ohmic values and current capacities, G-E IC9033 resistor units are available in elements of similar appearance and construction. Any intermediate ohmic values or capacity desired are easily obtained by the use of taps or by connecting IC9033 resistors in series, series-parallel, or parallel.

MOUNTING PROBLEMS ARE SIMPLIFIED because the resistors have uniform mounting dimensions over a complete range of ratings. Designed to give you greater flexibility, the IC9033 is ideally suited for applications such as load banks where resistors must cover a wide range of ohmic values and current capacities.

STURDY CONSTRUCTION of these resistors makes them particularly suitable for use on travelling cranes, portable equipment and other applications where vibration and sudden jolts are likely to be encountered.

FOUR FORMS OF THE IC9033 are available: smooth-wound, smooth-wound with variable slider, open-wound, and edgewound units. Each form has five sizes ranging from 6⅜ to 18⅜ inches, except Form F which is not made in the shortest length.



FORM A SMOOTH-WOUND UNITS are suitable for low current and high ohmic values.

Because the resistance wire on the Form A has uniform spacing achieved by tension winding, the unit has even heat distribution throughout, assuring the resistor of longer life. High mechanical strength is obtained through the use of a cylindrical core with a steel mounting rod extending through length of unit.

FORM B OPEN-WOUND UNITS are designed for higher current and lower ohmic values than the Form A units.

Short circuits between turns are virtually impossible in this unit. The core is cross-shaped with four projections having molded grooves which securely hold wire in place. The rugged porcelain body is further strengthened by a steel mounting rod extending through the unit's lengh.

FORM C EDGEWOUND UNITS are designed for 50 amperes maximum.

Alloy ribbon is employed as a resistor element in the Form C. It is helically wound, edgewise, and screwed to "I" shaped porcelain insulators with teeth and grooves in upper and lower edges. High heat dissipation is assured by extremely large surface areas offering very little ventilation restrictions. High current capacities are possible because of fewer turns per inch and large cross sectional areas.

FORM E SMOOTH-WOUND UNITS are the same as Form A but with a slider added.

FORM F EDGEWISE-WOUND UNITS range up to ratings of 96 amperes.

Like the Form C, this unit is wound around a one-piece porcelain core. Heavier ribbon is used to obtain higher ampere ratings.

Check These Features of G-E IC9033 Resistors

- √ **Wide Range of Ohmic Values and Current Capacities.**
- √ **Compact Design.**
- √ **All Parts Corrosion-Resistant.**
- √ **Low Resistance Welded Terminals.**
- √ **Permanent Electrical Characteristics.**
- √ **Shock Resistant Construction.**
- √ **Connections Easily Made on Accessible Terminals.**
- √ **Available with Mounting Feet, in Unit Boxes, and in Frames.**

For additional information on G-E IC9033 resistors see the coupon below.

General Electric Co., Apparatus Sales Division, Section A781-9, Schenectady 5, N. Y.

Please send me the following bulletins: for reference (x) for immediate project (√):

☐ **GEA-5994 LIMIT SWITCHES** ☐ **GEC-1302 DRUM SWITCHES**

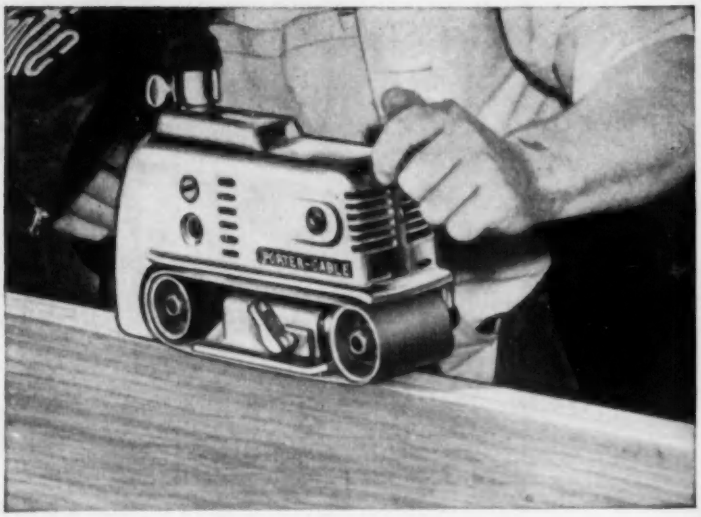
☐ **GEC-1292 RESISTORS**

Name..... **Company**.....

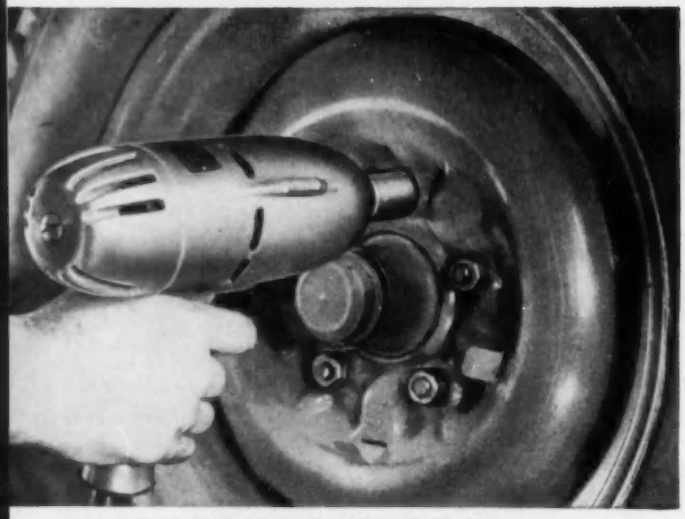
City..... **State**.....

General Electric Engineers Help

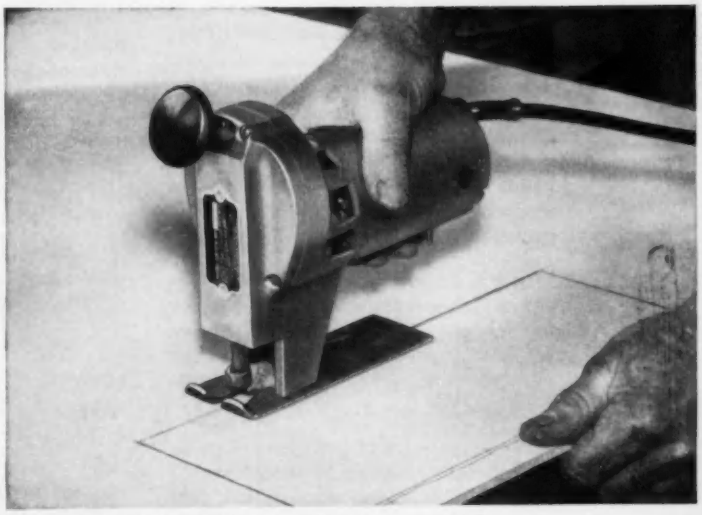
Spinner Edger, American Floor Surfacing Mach. Co., Toledo



Belt Sander, Porter-Cable Co., Syracuse, N. Y.

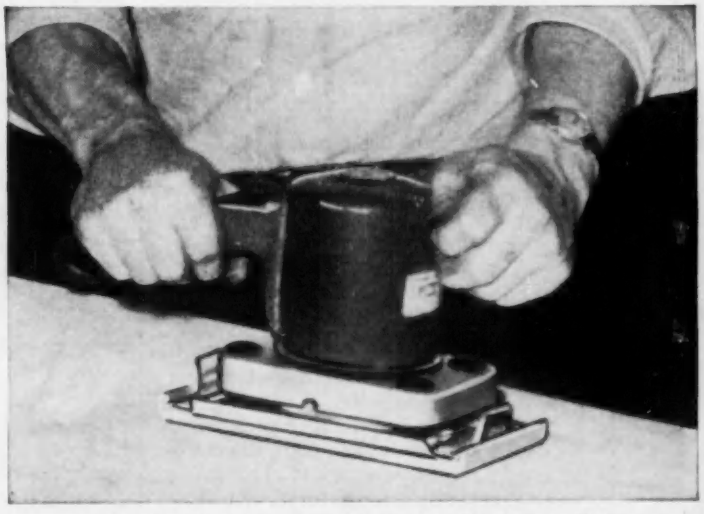


Impact Tool, Miller Falls Co., Greenfield, Mass.



Sabre Saw, Peninsula Tool Co., Menominee, Mich.

Garden Tiller, Rototiller, Inc., Troy, N. Y.



Smoothie Sander, Clarke Sanding Mach. Co., Muskegon, Mich.

Top Power-tool Manufacturers Solve Motor Application Problems

An Example of G-E Engineering Service Available to You

The eight popular "do-it-yourself" tools pictured here are all powered by General Electric fractional-hp motors. During their design, G-E engineers worked closely with customer engineers to assure proper motor application. As a result of this combined G-E product and engineering service, both tool manufacturers and tool users can count on top performance.

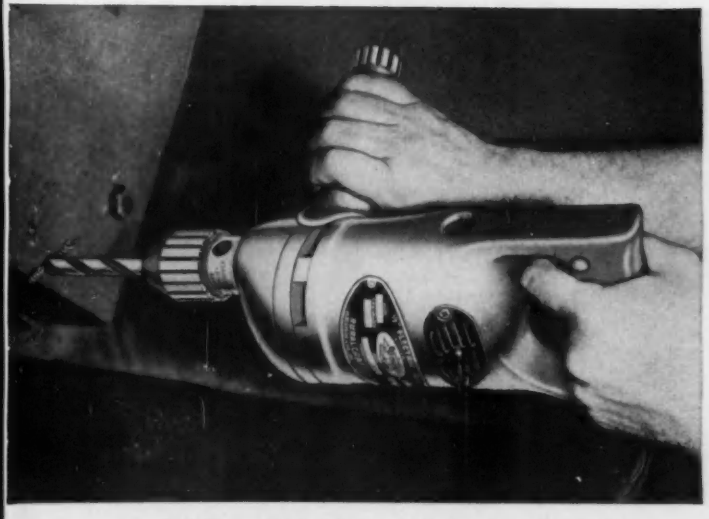
FOR SOME TOOLS, a slight modification of an existing G-E motor design filled the power needs. For others it was necessary to design special motor parts. In one case G-E engineers contributed a suggestion which led to complete tool re-design in order to assure top motor performance. In every case G-E fhp motor engineers—making use of G.E.'s unequalled development facilities—provided complete motor application service.

WHATEVER YOUR PRODUCTS—from aircraft components to plant process equipment to home workshop tools—you can get this same help on fhp motor application. And chances are that G-E experience will cover your specific area of need. For in designing, manufacturing, and applying over ***100,000,000*** fhp motors, G-E engineers have worked with customers on thousands of different products.

ACT TODAY to put your motor problems in the hands of the motor industry's leading application engineers. Just contact your nearest G-E Apparatus Sales Office. General Electric Co., Schenectady 5, New York. 704-58

Progress Is Our Most Important Product

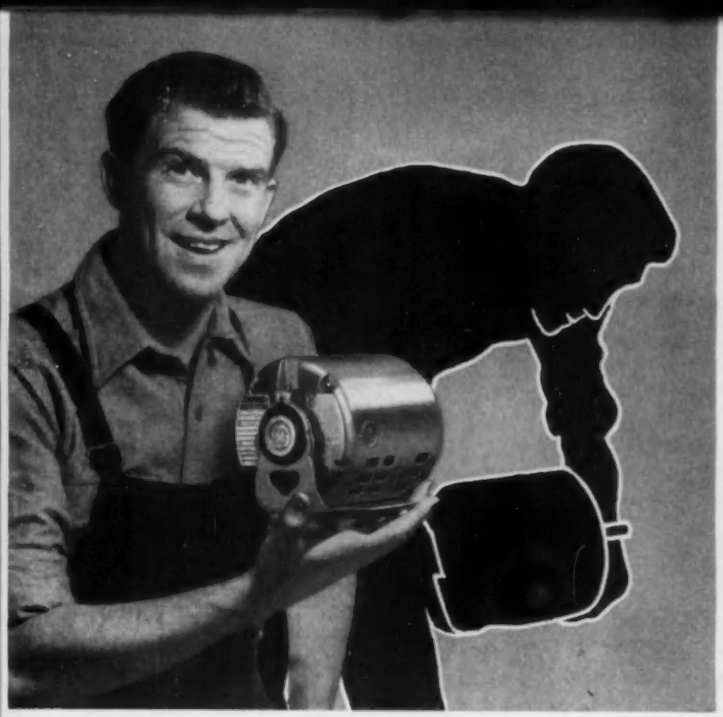
GENERAL ELECTRIC



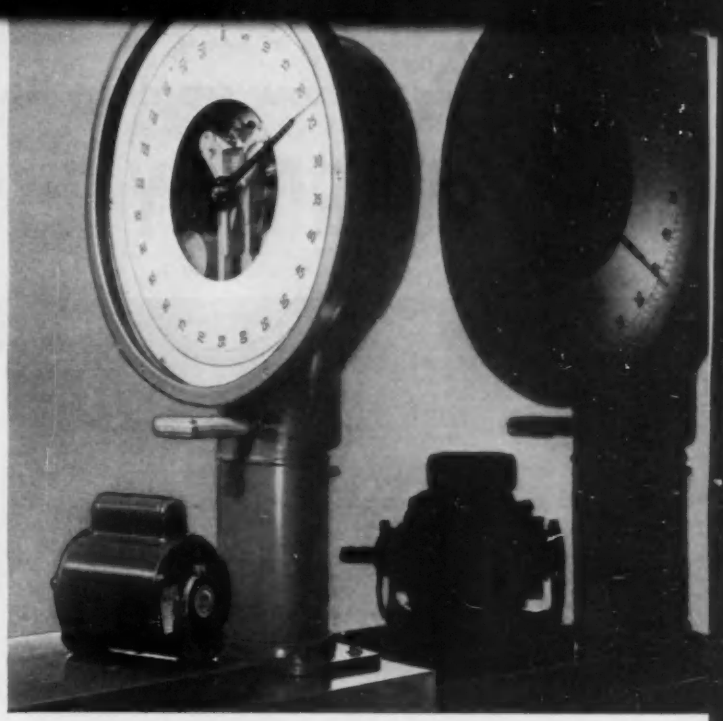
½" Sioux Drill, Albertson & Co., Inc., Sioux City, Iowa

Impact Tool, Ingersoll-Rand Co., Athens, Pa.

YOU SAVE ON MATERIAL COSTS—*and design better, more compact more saleable products*—when you take advantage of the significantly smaller size and lighter weight of today's G-E fhp motors. Hundreds of G-E customers already have!



YOU SAVE ON ASSEMBLY COSTS. Lighter and more compact, new G-E fhp motors are far easier to handle. Result: less fatigue for your workers, greater production efficiency.



YOU SAVE ON TRANSPORTATION COSTS because G-E motors on your products weigh up to 50% less than other makes. Add in savings due to lighter mountings or housings.

New General Electric motors help you cut material costs, improve products

Smaller, lighter G-E fhp motors save on assembly and shipping, too!

YOU SAVE THREE WAYS when all-new General Electric fractional-hp motors power your products: (1) On materials—because these G-E motors are up to 40% smaller, they permit you to use smaller mountings and housings. (2) On assembly—up to 50% lighter, they reduce handling fatigue, help boost assembly-line efficiency. (3) On transportation and storage—they cost less to ship, require less warehouse space.

MORE COMPACT, ATTRACTIVE PRODUCTS are another benefit of these new G-E motors. When re-designing, you can take advantage of their smaller size and lighter weight to improve your own products, make them more compact and saleable.

MOTOR LIFE INCREASED, TOO! New G-E fhp motors give you longer life and greater dependability as well as more compact power. They feature new design techniques and modern materials which mean *greater* motor protection, *reduced* motor maintenance, and *wider* motor usability. For example:

- New G-E insulation system provides superior protection against moisture, aging, and deteriorants through use of Mylar* polyester film slot-insulation, Formex** wire, Glyptal** varnish and Neoprene leads.
- New G-E lubrication system doubles lubrication life . . . on some applications no relubrication required.
- Quiet, all-angle G-E sleeve bearings permit operation of motors in any position, eliminate the need for many costly specials.

TO START SAVING with these popular new motors, contact your nearby G-E Apparatus Sales Office today. Or write for Bulletin GEA-5567 to General Electric Company, Section 702-11, Schenectady 5, New York.

*Dupont Trade-mark
**Reg. Trade-mark of General Electric Company

Progress Is Our Most Important Product

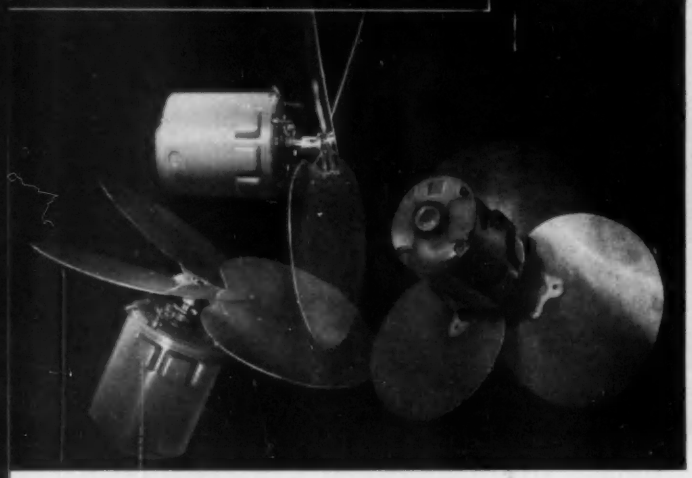
GENERAL ELECTRIC

SEE Four Typical G-E Motors ON NEXT PAGE

4 examples of how smaller, lighter G-E fhp motors

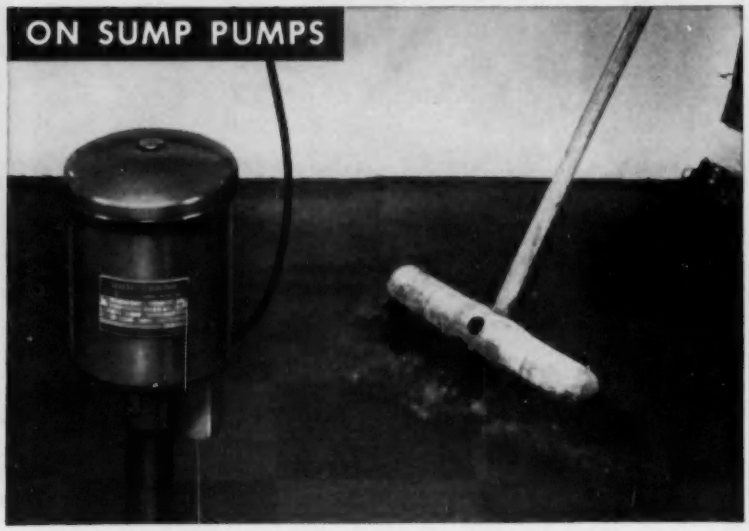
HELP IMPROVE YOUR PRODUCT DESIGNS

ON INDUSTRIAL FANS



MOUNTING IN ANY POSITION is possible with these G-E TEFC fan motors. All-angle sleeve bearings plus four permissible mounting arrangements (thru-bolt, cradle, resilient ring, band) cut your motor inventory. Doubled lubrication life; extended oiler at pulley-end simplifies maintenance. Ratings up to ½ hp, single-phase (Bulletin GEC-1264) and polyphase (Bulletin GEC-1265).

ON SUMP PUMPS

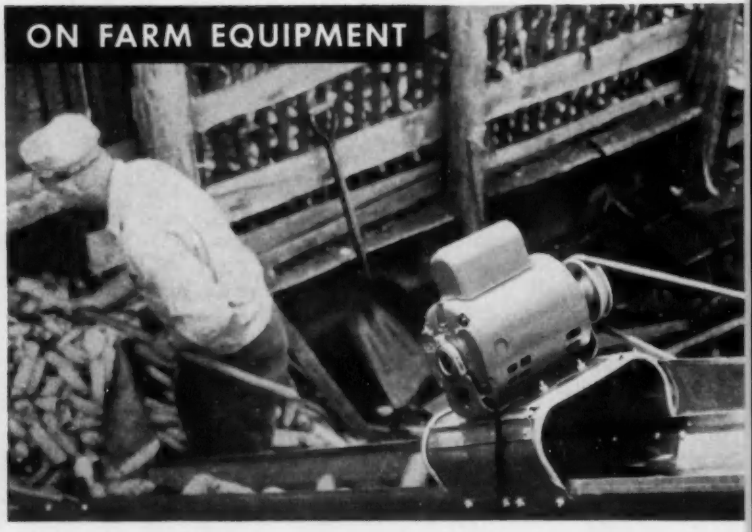


UNUSUAL RESISTANCE TO MOISTURE results from new insulation on this G-E ⅓-hp split-phase sump pump motor. New design provides modern appearance, permanent lubrication, improved ventilation. Changeable rotation minimizes service stocks. Precision ball bearings with large grease reservoir absorb heavy end-thrust loads. See Bulletin GEC-997.

ON SHOP EQUIPMENT

TEN-YEAR FACTORY LUBRICATION of these G-E totally enclosed fan-cooled motors means extra low maintenance. Special ball-bearing construction and new-type grease give long service, support heavy thrust loads on drill presses, lathes, other shop tools. Totally enclosed design helps protect against wood and metal dust particles. ⅙ to 1 hp, Bulletins GEC-855 and GEC-856.

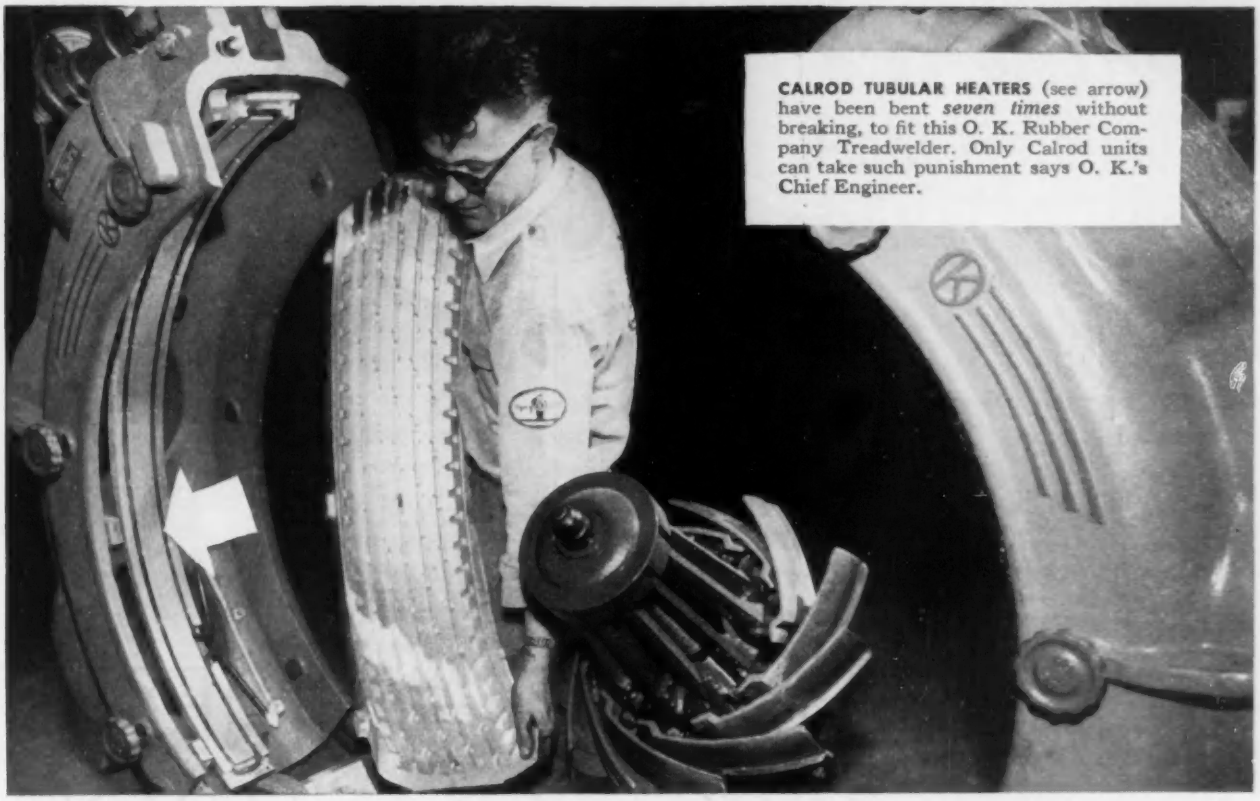
ON FARM EQUIPMENT



HIGH STARTING TORQUE and ability to operate in any position make this G-E capacitor-start motor ideal for pumps, poultry feeders, feed grinders, conveyors, and many other types of farm equipment. It features long-lasting all-angle sleeve bearings, sturdy, versatile base-mounting, and a new system that doubles lubrication life. ⅙ to 1 hp, Bulletin GEC-857.

FOR FULL INFORMATION on these and other G-E fhp motors, contact your nearby G-E Apparatus Sales Office. And write for Bulletins listed to General Electric Co., Sect. 702-18, Schenectady 5, N. Y.

GENERAL ELECTRIC



CALROD TUBULAR HEATERS (see arrow) have been bent *seven times* without breaking, to fit this O. K. Rubber Company Treadwelder. Only Calrod units can take such punishment says O. K.'s Chief Engineer.

Sturdy, Easily Bent G-E Calrod* Heaters Solve O. K. Rubber's Installation Problem

"We use G-E Calrod tubular heaters because they are rugged, yet easy to bend," says Elby E. French, engineer in charge at the O. K. Rubber Company, Littleton, Colorado.

"We use three of these heaters in our Treadwelder, a machine for recapping truck tires. We have to bend each heater seven times before final installation. Other heaters we've used couldn't take this punishment and had to be sent back to the factory and specially bent. This meant shipping costs and delayed production. Now we bend these Calrod units right in the shop. I know of no other heater that gives the heat we need for our job and still is as easy to bend without danger of breaking."

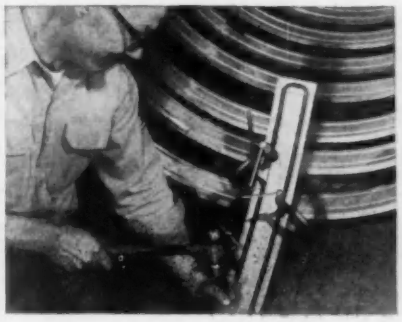
Like O. K. Rubber, solve your design and installation problems with General Electric Calrod heaters. Your nearby G-E Apparatus Sales Office is ready to help you. Call today and write for free bulletin GEC-1005, Calrod Heaters and Heating Devices, Sect. 720-135, General Electric Company, Schenectady 5, N. Y.

*Reg. trade-mark of the General Electric Company.

GENERAL ELECTRIC

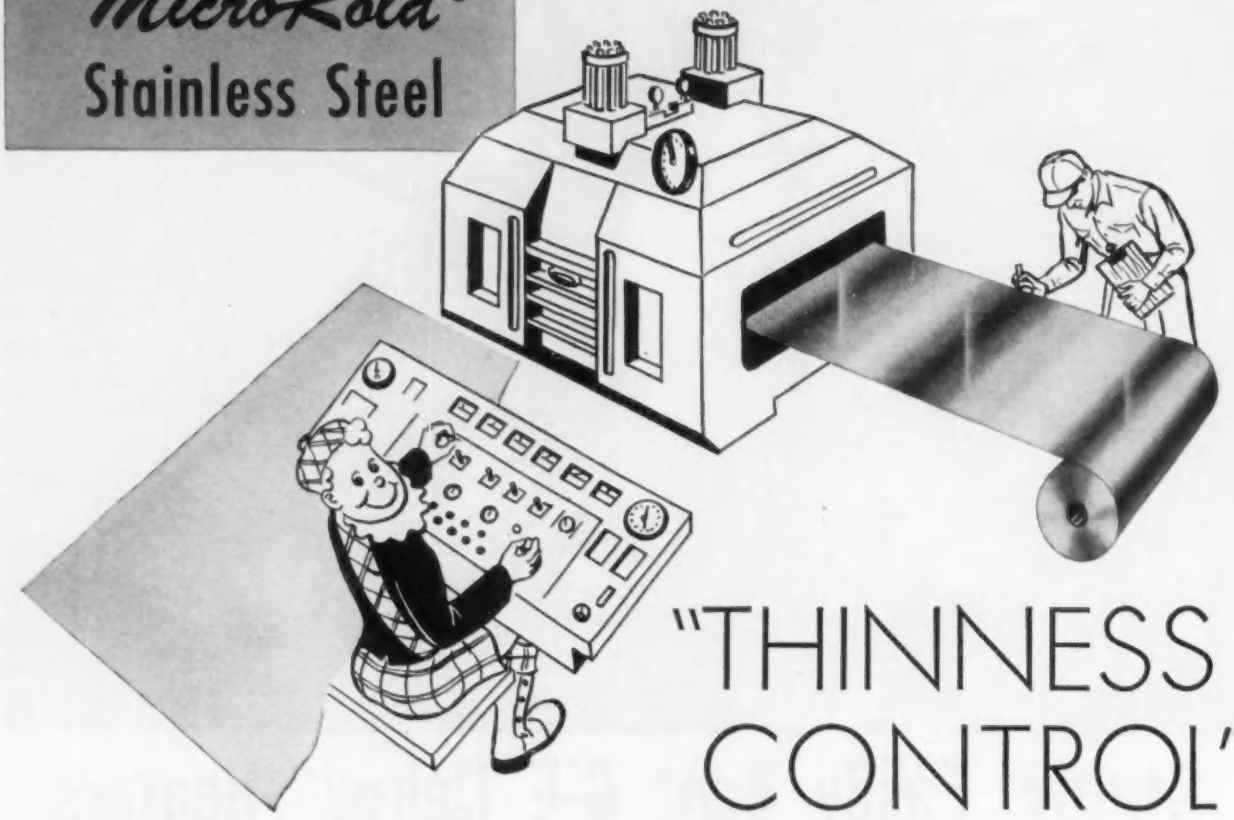
RUGGED HEATERS ARE EASILY BENT without breaking. Prior to shipment, G.E. anneals heaters in controlled atmosphere furnace to assure safer bending.

HEATERS ARE FITTED to aluminum ring to provide the exact heat required for retreading huge truck tires. Recapping machine is Underwriters' listed.



PRODUCT MADE POSSIBLE because of General Electric Calrod tubular units. Other heaters broke, could not do the job for O. K. Here, leads are taped in.

MicroRold® Stainless Steel



"THINNESS CONTROL"

provides strip *Quality* in SHEET *Sizes*

Remarkable uniformity of gauge in MicroRold Stainless Sheets up to 36″ wide.

The "Thinness Control" used in the manufacture of light gauge MicroRold Stainless Sheets assures you of the *same* dimensional accuracy as in strip stainless. Specified gauge thicknesses may be rolled in sheet sizes with tolerances as low as 3% average (plus or minus) as compared to the A.I.S.I. allowable of plus or minus 10%. This results not only in weight savings but also in fabricating economies.

With "Thinness Control" MicroRold's close adherence to a specified gauge will naturally result in a longer die life. Not only is MicroRold held closely to the specified thickness, but the "crown", or extra thickness in the center, is less in MicroRold than the "crown" in sheets rolled by conventional practice.

Regular use of MicroRold Sheet can give you more stainless area per ton or the equivalent area with lesser weight.

MicroRold Stainless Steel Sheets are available up to 36" wide and in gauges from .005 in commercial grades, finishes and temper.

Ask your steel warehouse distributor for MicroRold with "Thinness Control"

Washington Steel *Corporation*

Washington, Pennsylvania

Perspectives

DESIGN AND DEVELOPMENT

MILITARY TALKS BACK

The investigation by the Riehlman Committee on Who Should Control Military Research to all intents and purposes upheld the charges made by civilian scientists, and placed the blame of mismanagement squarely with the military (Perspectives, January, 1955). But those who defend the military control side say that the main point was missed; that while the findings of the Committee generally reflect on the management of defense research, the report does not really get to the fundamentals. It's easy to say that the Military has botched up the job, that changes are needed in the entire research organization, and that the answer is to allow the civilian scientists to have complete control. However, the military men who manage defense research, feel that all these criticisms do not take into consideration the complexity of research today.

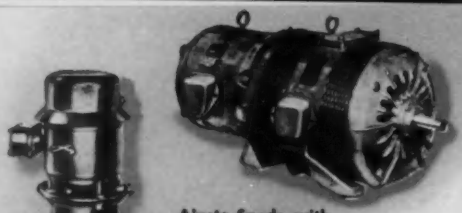
THE MANAGER'S VIEWPOINT

Quoting from the Riehlman report, under the argument for Military control: "The only way to build up military technological capability is for science to be intimately connected with the military program." Consequently, the military man is the first to admit that the control of defense research in the United States should be vested both in military and civilian men, if the job is to be done right. As has been shown, this attempt to equally distribute this control, while keeping the final decision in the hands of the military, has caused difficulties. Each administrator of any particular program brings his own background and experience to deal with the problems at hand.

Furthermore, the nation can get a coordinated program, which balances in the several ways that it should, only if the military and the civilian can work together. This effective balancing includes: (1) The right emphasis on the immediate tactical developments as opposed to the long research plans; (2) High enough research levels, as contrasted to production levels; (3) Coordination among the three military services, and among the technical branches which make up each service; and (4) A research program that is in harmony with the over-all levels of the government budget. The complexity of the cross-balancing and coordination which is needed for an effective program, is all too often overlooked by the scientist and congressman who stand ready to condemn defense research management.

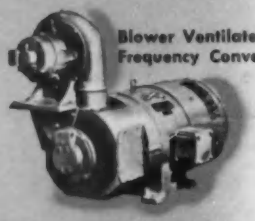
Another point not generally recognized, is that the troubles of defense research management are actually no different from the troubles which have plagued many companies. Some of these Military vs. Civilian problems, which have their counterparts in industry, are: technical personnel trying to sell their ideas to management; the extent to which research workers should be supervised; and how much time should be spent on applied research compared to the non-objective directed basic research.

(Continued on page 125)

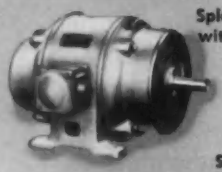


Ajusto-Spede with Eddy Current Brake

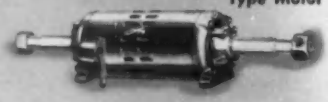
Single-Phase Pump Motor with Tripod Base



Blower Ventilated Frequency Converter



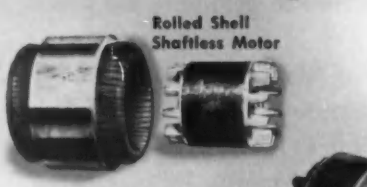
Splash-Proof Motor with Flange



Special Arbor Type Motor

Self-Cleaning Textile Motor

Gearmotor



Rolled Shell Shaftless Motor

Oil-Well Pumping Motor

In case after case, a special motor gives more flexibility, more production, greater economy!

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FIND out about special motors — how they help to step up machine performance. Call in a Louis Allis engineer.

He's an expert in motor design — knows control and drive characteristics. He's probably solved drive problems like yours for other Louis Allis customers. At any rate, he has a wealth of motor experience—experience that lets him make sound recommendations to you—experience that often helps you get improved product performance.

So, when you need special motors — regardless of electrical and mechanical characteristics, speeds or torque requirements — take advantage of Louis Allis' specialized know-how. Save time, save money, improve product performance. Call in the Louis Allis engineer near you.

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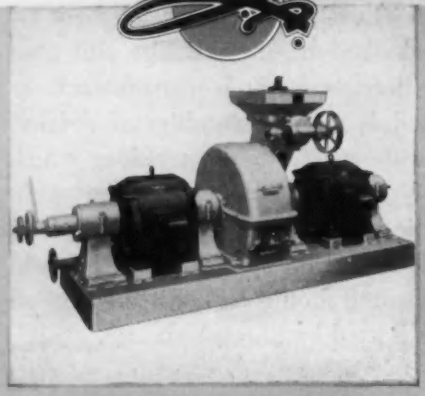
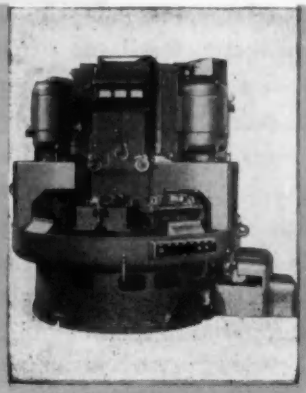
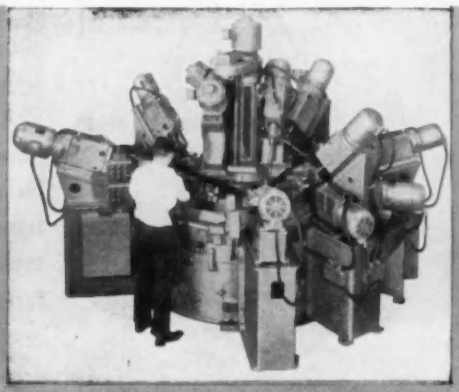


Two Louis Allis open, drip-proof, floor horizontal, shaftless attrition mill motors drive this double-runner attrition mill.



A Louis Allis frame-type, shaftless, squirrel-cage motor is built into the grinding heads of this vertical-spindle, rotary, automatic surface grinder.



Each of the sixteen heads of this automatic drilling and tapping machine has its own Louis Allis motor designed for the specific range and type of work handled by that particular head.

Perspectives

MORE RESEARCH TODAY

Research spending now represents several billion dollars per year of the government budget. In 1938, the allocation for the same type of research was little more than $100,000. The huge expansion started with World War II, and shows no signs of letting up.

But there is another important change. Since the war, many career officers have seen how valuable research really is. Many of them cannot grasp the full technical significance of many of the projects, but they are aware of the great changes caused by past discoveries, and realize the need for many more in the future. The individual managers of defense research have sold their bosses (i.e. the Military). The job that remains is keeping them sold—no small task.

THE REAL TROUBLE

During the committee hearings there were three defense Research Centers which were singled out for considerable criticism. These were the Air Force Development Centers at Cambridge, Mass. and Rome, N. Y., and the Navy's Special Devices Center on Long Island. The troubles at each were gone into at great length (A former civilian Technical Director at the Cambridge Center said; "Decisions were handed down that were just plain stupid"), yet, the basic difficulties were not mentioned.

The Rome, N. Y. center, for example, is an outgrowth of the split-up between the Air Force and Army radar development work originally carried on at Fort Monmouth. When it was decided to separate the Air Force work, the Army administrators manipulated the staff so as to keep the best men for themselves. Then, when the Air Force decided to move its personnel from Fort Monmouth in the New York metropolitan area to upstate Rome, many of the good engineers that remained, refused to leave. Just as the Rome laboratory was recovering from this difficulty, the personnel problems were complicated again by the Korean build-up. Problems at the Cambridge center were also attributed to a fast build-up.

At the Navy's Special Devices Center, the administrators attributed the troubles to the fact that some important work was not going well. This problem served to throw salt on the wounds opened by feuds between the top civilian and military managers at the Center.

DEFENSE DEPARTMENT MANAGEMENT

But these laboratories are not considered typical of the entire research set-up—even though many complaints are heard from scientific workers elsewhere. The military views this with the attitude, "Well, a scientist always complains about things as they are; that's why he's a scientist." Furthermore, a number of military men feel that the new top management of the Defense Department is working over its program of coordination to a point where the control of research and development will be more effective than it has been. Some recent additions to the military's bag of tricks, (i.e., radar systems that will pick up low flying planes; and another radar unit that will completely blot out the radar bombsight of attacking bombers) show that new ideas and weapon concepts are resulting from the present research partnership between the military and the civilian scientists.

TINNERMAN

Speed Nut

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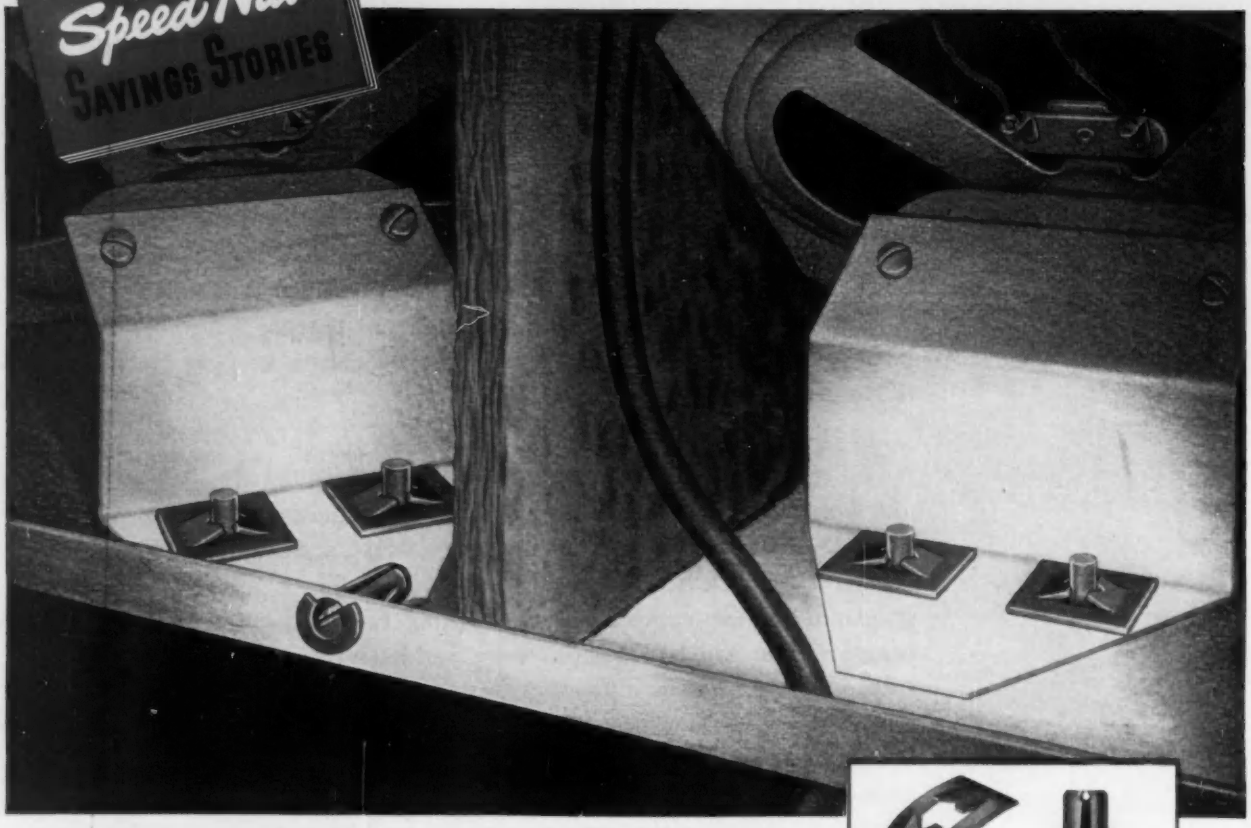
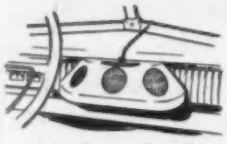


SPEED NUTS turn up speaker "volume" with 51% time saving!



Heavy demand for the new Ezell Stereophonic Sound Speaker made it necessary for the Lone Star Plastics Company, Inc., Fort Worth, to find production short cuts. Produced for the Bishop-Green Manufacturing Company, Dallas, this in-a-car speaker for drive-in theatres was assembled with 15 SPEED NUT brand fasteners. The result: faster, easier assembly with savings of 51% in time, 34% in material costs!

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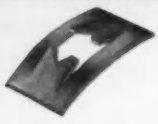
Chances are similar SPEED NUT savings can be made in your own product assemblies. Call your Tinnerman representative for complete details!

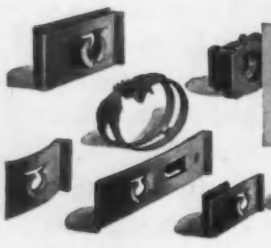


PUSH-ON SPEED NUT

TUBULAR SPEED CLIP

The use of SPEED NUT brand fasteners results in substantial savings in assembly time, cost of materials, and materials handling. For example, SPEED NUTS eliminate costly threaded inserts, make faster, easier attachments in blind locations and permit greater design flexibility. A complete range of types and sizes available.

Send for your copy of SPEED NUT "Savings Stories," and descriptive literature on the above fasteners. TINNERMAN PRODUCTS, INC., Box 6688, Dept. 12, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners Ltd., Hamilton, Ontario. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S. A.—7 rue Henri Barbusse, Levallois (Seine).



TINNERMAN Speed Nuts®

MORE THAN 8000 SHAPES AND SIZES

Fruitful Troublemakers

THERE ARE MANY kinds of troublemakers in this world but perhaps the most fruitful of them all is the one who creates something new and different. It isn't that the person himself is of a cantankerous nature. It is his new creation that in itself causes all the trouble in one way or another.

The introduction of textile machinery caused riots, some cities prohibited the first automobiles from using the streets, early locomotives frequently killed cows that strayed upon the track. In addition to these kind of troubles, new things often cause economic disruptions, troubles for business men and the public alike.

The automobile practically put an end to the horse shoe business and carriage manufacture. It almost made museum pieces out of many things such as whips, whip-sockets, carriage blankets and whiffletrees. Not content with putting a lot of people out of business, the automobile created further troubles for everybody by increasing tax rates and taxing things that were formerly tax free, such as gasoline. And the nation had to go to the trouble of building lots of roads.

Turning from the facetious to the serious side of the picture, business owes its progress to fruitful troublemakers. One company has the slogan "Progress is Our Most Important Product." A corallary to this might read "Fruitful Troublemaking is Our Biggest Pleasure."

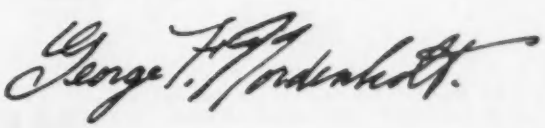
Every new product requires changes in production machinery and plant layout. Changes from one type of construction, such as forging, casting, welding or die casting, to another type of construction might require new shops or dismantling an existing one.

In the light of the repercussions that might result from the introduction of something new, it is not surprising that in many companies management is extremely slow to approve proposed new development. Sometimes such slowness might be justifiable. But only too often the sluggishness can be attributed to excessive conservatism, lack of knowledge, or even lack of courage on the part of management.

Unfortunately, the fruitful troublemakers often are not given the opportunity to sell the management on the virtues of their brain child. Or perhaps the genius has an exaggerated opinion of the value of his creation. Regardless of which is closer to the truth, it is management's duty to give serious study to the proposals of the "troublemakers," get outside advice if necessary, and above all, to give the "troublemaker" a chance to sell management on his ideas.

If the management displays neither vision nor courage and is looking only for ideas that require no capital, no changes in production layout, no changes in sales set-up and no risk, the company can be classed as completely negative.

Fruitful troublemakers in the employ of such a company should "pull up stakes" quickly and move to a progressive company. Fruitful trouble is the root of all progress. It both stimulates progress and results from progress. The company that aims to avoid it offers little opportunity for creative engineers. Of course the engineer must also do his part in presenting his ideas.



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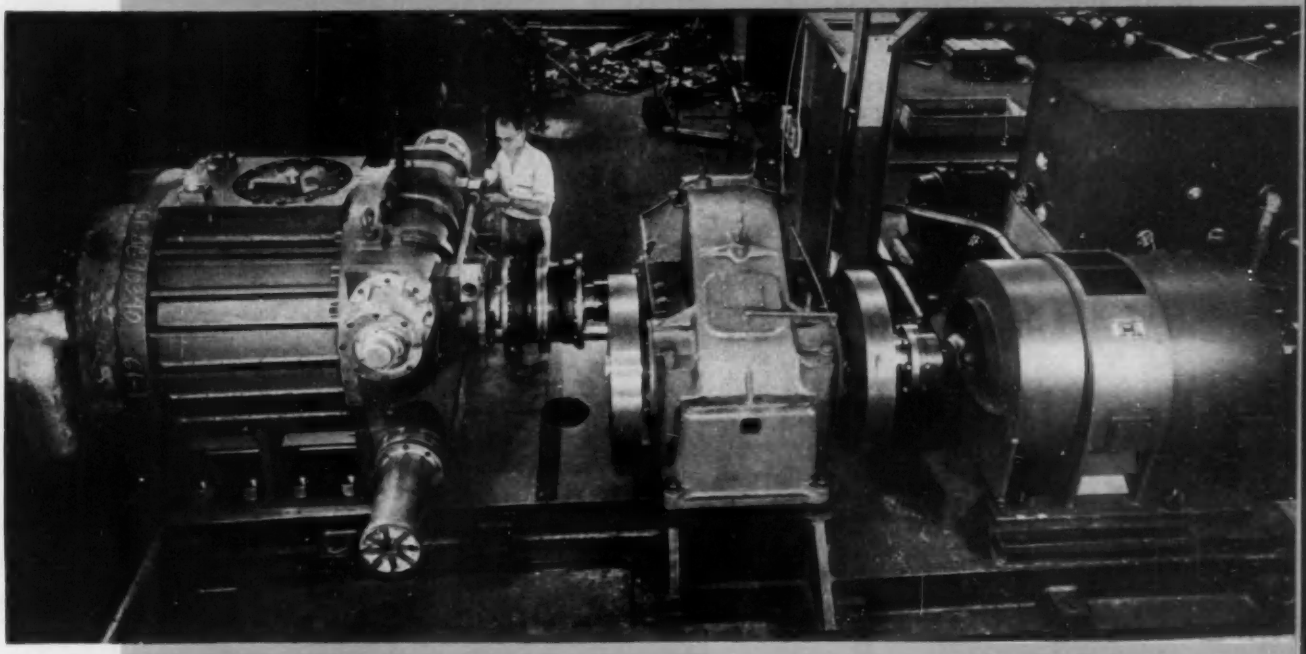
In fact, New Departure *ball* bearings play an important role in just about *every* product with moving parts. For more than 50 years, manufacturers everywhere have counted on New Departure for bearings.

Why this confidence? It's a matter of living up to a name. It means being *first* with new departures—like the Sealed-for-Life *ball* bearing. And New Departure will be ready tomorrow with the *finest* bearings . . . *first!*

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

NEW DEPARTURE
BALL BEARINGS

NOTHING ROLLS LIKE A BALL



HYDRAULICS

for high horsepower applications . . .

. . . require different types of equipment and application methods than are used with smaller units, but offer:

(1) efficient and precise control of large forces,
(2) flexibility and ease of automatic cycling,
(3) widest range of speed adjustments.

Included are sample calculations for determining pump and motor sizes. →

M. A. HAYDEN
Assistant General Manager, Waterbury Tool Division, Vickers, Inc.

LARGE CAPACITY HYDRAULIC UNITS capable of handling hundreds of thousands of horsepower are still principally in the "custom" stage, although designs now have been standardized for some sizes. They have had an extensive background of use in the marine and military fields and have been applied successfully in heavy gun turrets, heavy duty ship steering, airplane elevators, catapults, large hoists, special purpose locomotive and heavy machinery drives; however, they are still new to most of the other industries.

Their many unique operating characteristics may be the key to improvement in existing machinery especially in the fields of large production machinery; heavy duty cranes, hoists and elevators; and high performance propulsion drives for locomotives, tanks and ships. Some of the advantages of large capacity hydraulic units are:

1. Finger-tip control of large forces and power. In general, a hydraulic system will accelerate, decelerate or reverse faster than any other method of power transmission; it can be remotely or manually controlled by small forces; and can furnish extremely accurate positioning of a reciprocating or rotating member.

2. The widest range of speed adjustments of any existing power transmission system. Speed adjustments are stepless and accurate and large ratio reductions are possible between input and output without using gears. High horsepower hydraulic motors are capable of operating smoothly under load down to 1 rpm.

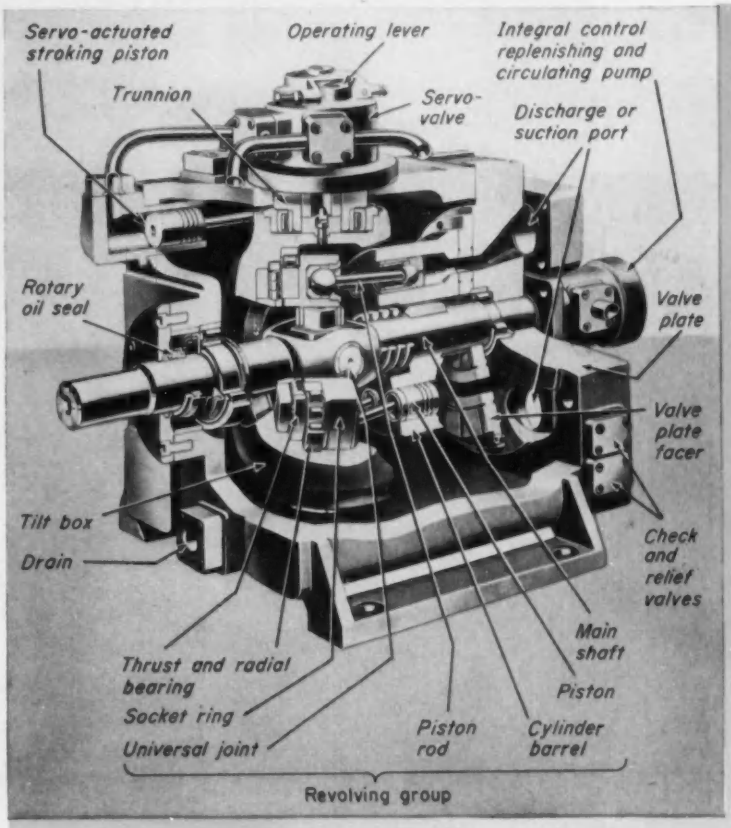


Fig. 1—Cutaway section of heavy duty variable displacement pump with servo control. Delivery may be varied from zero to maximum in either direction of oil flow without changing the input direction of rotation.

3. Transmission of forces over considerable distances and around corners without appreciable losses or complicated mechanisms; and the transmission of more power per unit of weight and bulk than any other method.

4. High operating efficiency. Overall mechanical efficiency of a high horsepower hydraulic pump or motor of the type shown in Fig. 1 exceeds 92 per cent at full load; volumetric efficiency is 97 per cent at 3,000 psi; torque efficiency of pump when used as a hydraulic motor exceeds 95 per cent at rated pressure; and overall mechanical efficiency of a hydraulic transmission (pump and motor) can exceed 85 per cent at full load.

5. Elimination of problems of shock and vibration. Action is smooth and motion occurs without the slack which is inherent to machine mechanisms.

6. Constant-horsepower output through all or part of a speed range, and if desired, constant-speed output from a variable-speed input.

7. The ability to stall under load indefinitely. Overload protection is adjustable and instantaneous and permits full torque or thrust to be exerted while stalled.

8. Ease of adapting the unit to automatic cycling control by hydraulic, electrical or mechanical means.

9. Flexibility as to the location and mounting position of the hydraulic unit.

10. Wide operating temperature range. Normal range is 20 to 140 F but with proper oils, units will operate satisfactorily through minus 30 to plus 170 F or higher.

The application of hydraulic equipment to machinery requiring relatively high horsepower often involves different types of equipment and application methods than are normally used with smaller capacity hydraulic equipment. For example, by-passing of oil for speed, torque, thrust or acceleration control, reversing valves for directional control, natural dissipation for heat control, and direct manual operation for operator control, are preferably not used in high horsepower hydraulic circuits.

Speed and Direction Control

By-passing of oil creates heat. Where the amount of energy converted into heat is large, as in large capacity hydraulic systems, heat dissipation becomes a serious problem. To minimize this problem, and avoid by-passing of oil, the control of speed is best handled by varying the displacement of the pump, and the control of acceleration by controlling the rate of change of pump displacement.

Reversing valves encounter serious problems in shock and control where the volume is large and pressure is high. Satisfactory reversing valves have been built for large

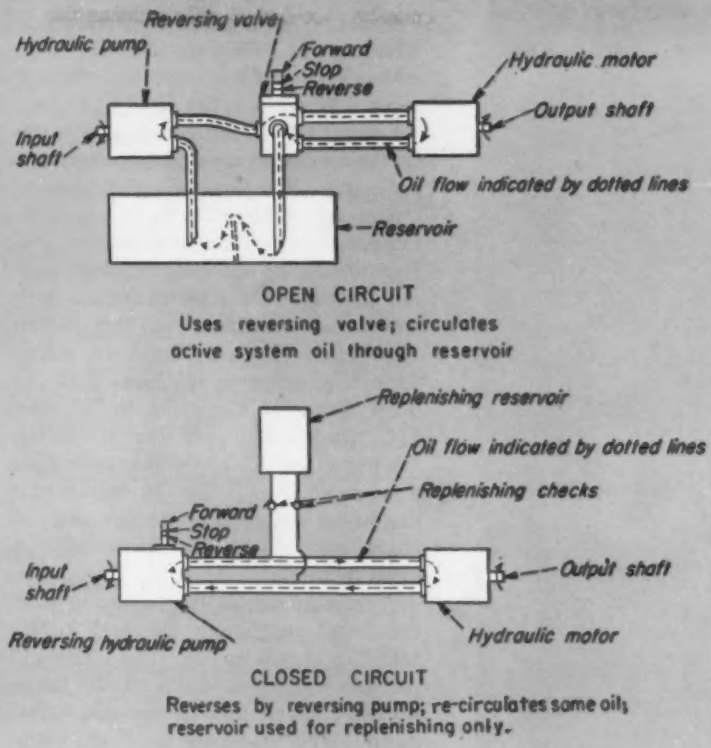


Fig. 2—Comparison of open and closed circuits. The flow of oil is indicated by dotted lines. Open circuits require reversing valves in place of reversing pumps but have some advantage in providing better circulation of oil for heat dissipation.

capacity applications but they do not equal the performance of reversing pumps for smooth, shockless directional control.

One type of unit that meets these requirements and can also furnish a combination of high displacement rate and high pressure with high efficiency is the axial piston rotary unit shown in Fig. 1. Such units operate either as a pump or motor and are furnished for fixed or adjustable displacement per revolution. As pumps, variable units are reversible without changing the direction of rotation, and as motors, fixed or variable units are reversible by changing the direction of oil flow. These units have a maximum operating pressure rating of 3,000 psi (normal range is 1,200 to 2,000 psi) and have been built with capacities up to 2,300 gpm and 4,000 hp.

Temperature Control

When dealing with large horsepowers, the energy losses which are converted into heat are often larger than can be dissipated normally by the system, particularly when a closed hydraulic system is used. For example, a closed system hydraulic transmission when handling 500 hp at an overall efficiency of 85 per cent is converting about 75 hp into heat. If the loading or service is intermittent, no heat exchanger may be required. However, if the normal radiation of the system is inadequate, supplemental heat dissipation may be obtained by circulating reservoir oil through a heat exchanger and through the cases of the pump or motor or both.

Single vs Multiple Pumps

In the past, pumps of large capacity were either not available or too costly, and multiple pumps were used in their place. As prices for large capacity pumps were reduced because of increased demand, there remained a reluctance on the part of many machinery builders to accept the engineering costs of redesign. They justified this on the basis that with multiple pumps, if one should fail, the machine could continue to operate. However, multiple units have the disadvantage of requiring considerably more space and increasing the complexity of valving, piping and controls. Perhaps the greatest disadvantage is that the practice usually eliminates the possibility of using a closed system, which is often the best system for large machinery from an operating and control standpoint. Applications of high horsepower which involve close speed control or good reversing control, are preferably done with a single reversing pump in a closed system.

Open vs Closed Circuits

The principal advantage of the open circuit is better circulation of oil for heat dissipation. This advantage disappears as the system becomes larger because the amount of heat to be dissipated exceeds the capacity of the reservoir and the system. Open circuits require reversing valves which are not always satisfactory for handling large volumes of oil (see Fig. 2). It is interesting to note that in the industries where experience with large capacity hydraulic systems is extensive, closed systems are used almost exclusively.

Direct Pumping vs Accumulators

Where the system demand is intermittent, and where the functions involved all require the same operating pressure, accumulator systems have been used economically because they permit the use of a small pump operating steadily in place of a much larger one.

On the other hand, accumulator systems preclude the possibility of a closed circuit and are often used where they are not efficient and thus contribute to the heat dissipation problem. For example, where an accumulator system is used with functions requiring widely different operating pressures, the storage pressure of the accumulator will be determined by the function requiring the highest operating pressure. When the higher pressure is used to perform a function requiring lower pressure, the differential is converted into heat and this can represent large amounts

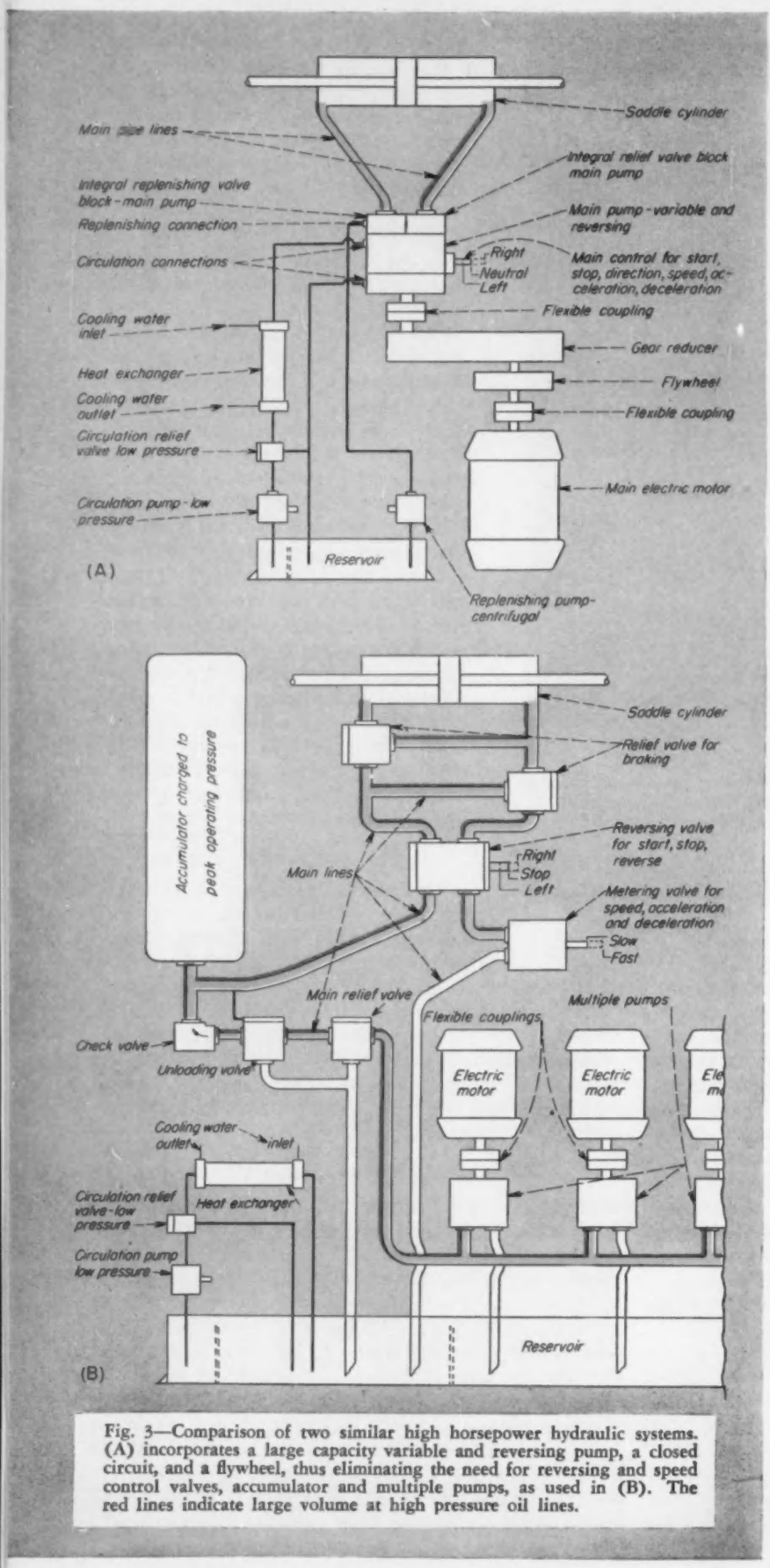


Fig. 3—Comparison of two similar high horsepower hydraulic systems. (A) incorporates a large capacity variable and reversing pump, a closed circuit, and a flywheel, thus eliminating the need for reversing and speed control valves, accumulator and multiple pumps, as used in (B). The red lines indicate large volume at high pressure oil lines.

of energy in large hydraulic systems.

Where the advantages of an accumulator are desired while retaining the advantages of a reversing pump in a closed system, the problem may be solved by using a flywheel on the input to a reversing pump with a maximum capacity equal to the maximum volume requirement of the system. The flywheel, acting as an accumulator, will give up its energy in the exact amount required, even for functions requiring lower operating pressure, without adding to the heat dissipation problem of the hydraulic system. This flywheel arrangement is being used on several large tube reducing machines built for Tube Reducing Corp., by E. W. Bliss Co., using 2,300 gpm pumps. While the pumps on this application sometimes draw more than 3,000 hp, the electric motors are only 500 hp on one size machine, and 700 hp on the other. (See cover picture).

A circuit diagram illustrating most of the design suggestions discussed in this article, is shown in Fig. 3(A). This circuit is a simplified version of the saddle hydraulic circuit used in the tube reducing machine shown on the front cover. Fig. 3(B) shows a circuit diagram of the same system, but without a reversing pump, closed circuit or a flywheel.

Economics of Price

Hydraulic equipment in the range of 100 to 200 hp are available as stocked items; for higher horsepower, the market is not broad enough nor the designs sufficiently standardized to build for stock.

In the future, as the market develops, prices of large hydraulic equipment can be expected to follow the pattern of smaller equipment. At present, prices for fixed displacement pumps and motors are approximately $15.00 per hp; reversible and variable pumps and motors are as low as $25.00 per hp; and complete variable speed transmissions (reversible) are approximately $40.00 per hp. Hydraulics has the potential of having the lowest cost per horsepower of any method of variable speed power transmission and control now in use.

Calculating Pump and Motor Sizes

TYPICAL PROBLEM: To determine the pump and motor sizes to operate a hoist meeting the following specifications:

Normal Load: 15,000 lb cable pull at 220 ft per min

Overload: 22,500 lb cable pull at 100 ft per min

Light Line: 25 per cent of normal cable pull at 400 ft per min

Given:

Radius of cable drum = 13 in.
Gear reduction ratio to drum = 14.7 to 1
Gear reduction efficiency = 89 per cent

Formulas: Horsepower output of pump or A-End:

$$hp = \frac{PQ}{396{,}000} \quad (1)$$

Horsepower output of motor or B-End:

$$hp = \frac{TN}{63{,}000} = \frac{PSN}{100{,}000} \quad (2)$$

Torque developed at motor or B-End:

$$T = \frac{63{,}000\ hp}{N} = 0.63\ PS, \text{ in.-lb} \quad (3)$$

Theoretical displacement using size number:

Pump or A-End = $4.52\ S$, in.^{3}/rev (4)
Motor or B-End = $4.35\ S$, in.^{3}/rev (5)

where:

S = displacement constant (Waterbury Size Number), in.^{3}
P = pressure, psi
N = revolutions per min
T = torque, in-lb
Q = discharge of pump, in.^{3}/rev

1. *Type of Circuit*

This application should employ a closed circuit with a variable and reversible pump in order to give the close control of start, stop, reverse, acceleration, deceleration and adjustable speed required on a hoist. Either a fixed or variable displacement motor may be used but a fixed displacement motor will be used in this example so that all controls will be centered in the pump.

2. *Determination of Motor Size*

It is desired to pick a hydraulic motor large enough to handle extremes without a gear change. Thus, the motor will have to run at the maximum speed (light line) and develop the maximum torque (overload) even though these two conditions do not occur simultaneously.

Revolutions of drum at 400 ft/min = $\frac{400\ (12)}{2\pi\ R} = 58.8$ rev/min

With a 14.7 to 1 gear reduction:

Max rpm hydraulic motor = 58.8 (14.7) = 865 rpm

By consulting Table I, which contains a chart of standard hydraulic motor sizes that are manufactured by the Waterbury Tool Division, it is seen that this speed is within the limitations of all units

Table I—Table of Hydraulic Motor Sizes

Size Number	Maximum RPM	Maximum Torque (Intermittent) in-lb	Moment of Inertia lb-in.^{2}
1¼	1750	2350	150
2½	1450	4700	200
5	1200	9450	570
10	1000	18,900	1,970
15	900	28,300	4,040
20	825	37,800	6,700
35	720	66,000	18,000
50	650	94,500	34,000
75	580	141,000	70,000
150	480	283,000	237,000
300	400	566,000	809,000

Table II—Table of Hydraulic Pump Sizes

Size Number	Rated RPM	Maximum GPM	Maximum hp (Intermittent)
1¼	1200	28	50
2½	1200	56	100
5	1200	112	200
10	900	170	300
15	720	200	350
20	600	230	400
35	600	400	700
50	514	500	900
75	514	750	1300
150	450	1300	2300
300	400	2300	4000

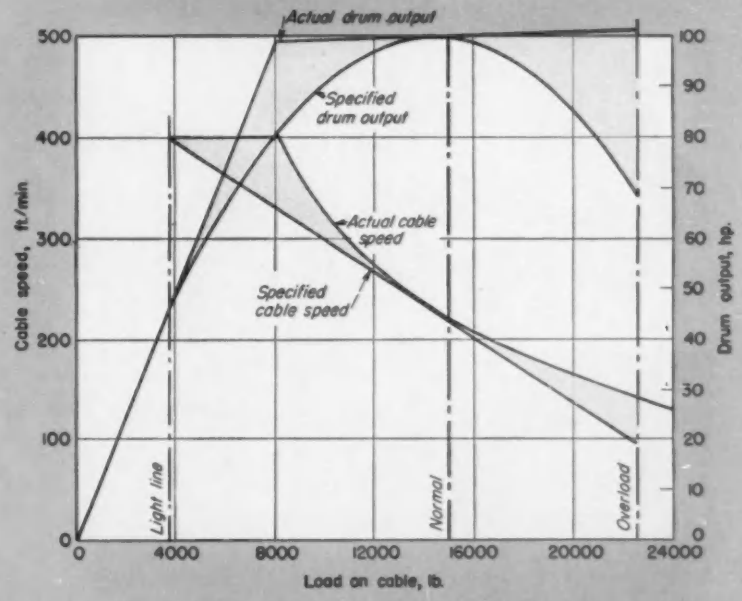


Fig. 4—Performance chart of a hoist using a pump with an automatic horsepower limiting device. Shaded areas represent amounts by which actual performance exceeds specified performance even with a limiting device.

through size 15.

$$\text{Max torque of motor} = \frac{\text{drum torque}}{\text{efficiency} \times \text{gear reduction}}$$

$$= \frac{22{,}500 \text{ lb} \times 13 \text{ in.}}{0.89 \times 14.7} = 22{,}300 \text{ in-lb}$$

Since this maximum torque is an overload condition, an operating pressure is selected near maximum, P = 2,500 psi.

From Eq (3)

$$S = \frac{22{,}300}{0.63 \times 2{,}500} = 14.2$$

From Table I, the nearest Size Number is 15. Recalculation of maximum pressure using size 15:

$$P = \frac{T}{0.63S} = \frac{22{,}300}{0.63(15)} = 2{,}360 \text{ psi}$$

Calculation of normal torque to check that the pressure is not too high for continuous operation will show (using same steps as above) that for 15,000 lb cable pull, the required operating pressure for size 15 is 1,570 psi, which is satisfactory.

3. Determination of Variable Displacement Pump Size

The pump must be of sufficient capacity to drive the hydraulic motor at speeds up to maximum and also develop the maximum operating pressure, even though the two conditions do not occur simultaneously.

Using Eq (5):

Displacement per rev of size 15 = 15 x 4.35 = 65.2 in.³/rev. Using 98 per cent volumetric efficiency each for pump and motor, volume required at pump for 865 rpm of motor equals:

$$\frac{865 \text{ rpm} \times 65.2 \text{ cu in. per rev}}{0.98 \text{ pump eff} \times 0.98 \text{ motor eff}} = 58{,}800 \text{ in.}^3\text{/rev}$$

Assuming 875 rpm input to pump, displacement per rev for pump equals:

$$\frac{58{,}800 \text{ cu in. per min}}{875 \text{ rev per min}} = 67 \text{ in.}^3\text{/rev}$$

Using Eq (4):

$$\text{Pump size number, } S = \frac{67}{4.52} = 14.85$$

Nearest size is 15 (from Table II)

The reason why hydraulic pumps and motors in sizes capable of handling up to 350 hp are necessary to handle this problem involving a maximum of only 100 hp output is because the various power outputs were required at various operating speeds. A gear changer would allow the use of smaller hydraulic units but would result in a more complicated and possibly a more expensive unit.

The pump for an application of this type may be equipped with an automatic horsepower limiting device which overrides the manual control when necessary to keep the horsepower output from exceeding a pre-set maximum. The operating curves (specified vs actual) for this application, with an automatic horsepower limiter on the pump are shown in Fig. 4. These actual curves include corrections for supercharging pressure. Fig. 5 shows the completed hoist power unit.

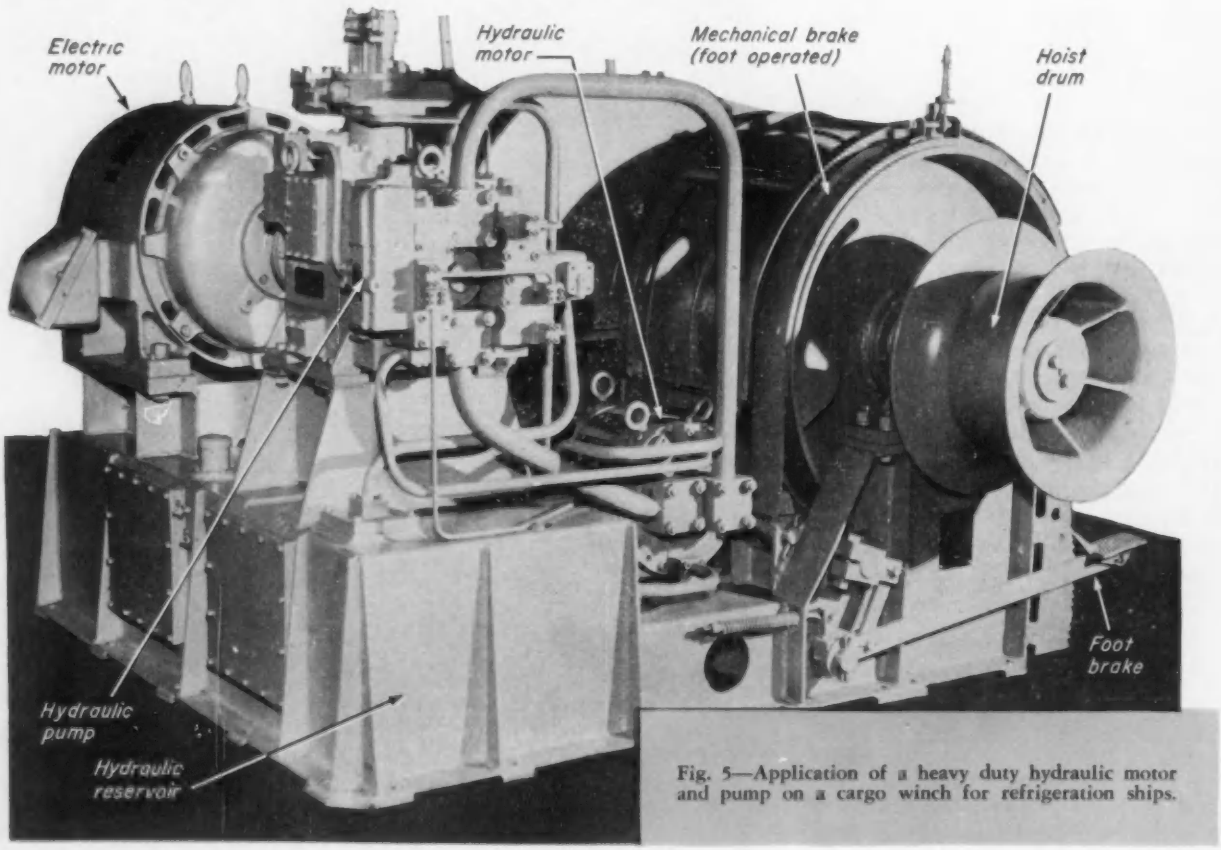


Fig. 5—Application of a heavy duty hydraulic motor and pump on a cargo winch for refrigeration ships.

TYPICAL APPLICATIONS REQUIRING REGULATED LINE VOLTAGE

- Production and laboratory testing of motors, appliances, machines, etc.
- Electrical laboratory uses: heat runs, photometric measurements, etc.
- Calibration of thermostats, circuit breakers.
- Precise electrical control of ovens.
- Industrial X-ray equipment.
- Blueprinting, photoprinting, and microfilming equipment.
- Ultra-precise grinding equipment.
- Electronic computers.
- Communications equipment and related electronic equipment such as radio transmitters and radar.
- Induction heaters.

A-C Voltage Regulators

Equipment performance can be improved and reliability of laboratory and production test data increased by using regulators to stabilize supply voltages. Selection of proper regulator is governed by nature and size of regulator load, rapidity of response, preciseness of regulation, allowable cost per kva, and adaptability to special electrical ratings.

WILLIAM P. CARPENTER
Chief Engineer, Superior Electric Co.

REGULATION of a-c power sources is of important concern in two areas. First, unless line voltages are maintained at design values during laboratory or production testing of motors, appliances, machines, or other equipment, data obtained may provide misleading performance characteristics and capabilities. Second, several types of electrical, electromechanical, and electronic equipments can be voltage-sensitive. When these equipments are connected to convenience outlets or power sources beyond the manufacturer's control, fluctuating or sustained high- or low-voltage operation can produce the following unwanted effects:

1. Impaired or erratic operation.
2. Failure of equipment parts or components, with consequent down-time.
3. Increased maintenance and repair costs.
4. Reduction in equipment life.

As a result, the designer must determine if supply-voltage variations within or exceeding recommended NEMA limits (± 10 per cent for commercial power; − 5, + 10 per cent for lighting) affect his equipment. This is important because local user conditions, such as intermittent or sustained heavy loads, long feeder runs, or multiple-customer use of common facilities may cause excessive transient or sustained departure from design-voltage values.

To obtain properly regulated voltages for test purposes, line-voltage regulators can be applied at the incoming line terminals of a localized plant or laboratory area, or at the equipment undergoing test. For equipment affected by line-voltage changes, regulators may be installed at the point of customer use, or may be included as an integral part of the design. To provide regulated voltage for loads of less than 25 va to more than 100 kva, four general types of regulators have been developed, namely: (1) induction voltage regulator; (2) ferromagnetic-resonant transformer regulator; (3) electronically-controlled saturable-reactor regulator; and (4), electronically-controlled electromechanical regulator. The advantages, disadvantages, and principal uses of each type are summarized in Table I.

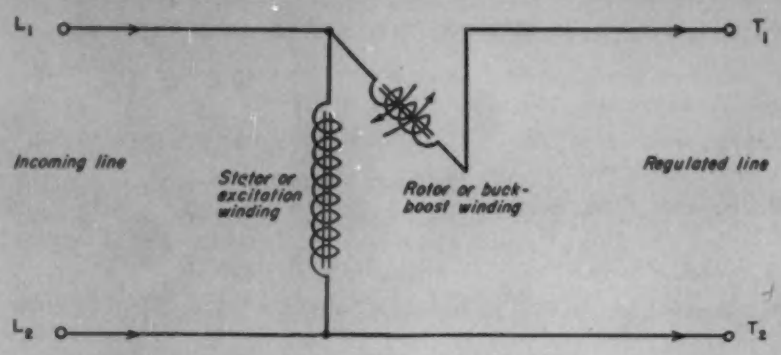


Fig. 1—Circuit diagram of induction voltage regulator. Magnitude and polarity of induced rotor voltage depends on direction and angular displacement of rotor from a null position. Line voltage is regulated by turning rotor, manually or automatically, so that induced rotor voltages add to or subtract from line voltage to maintain the desired value.

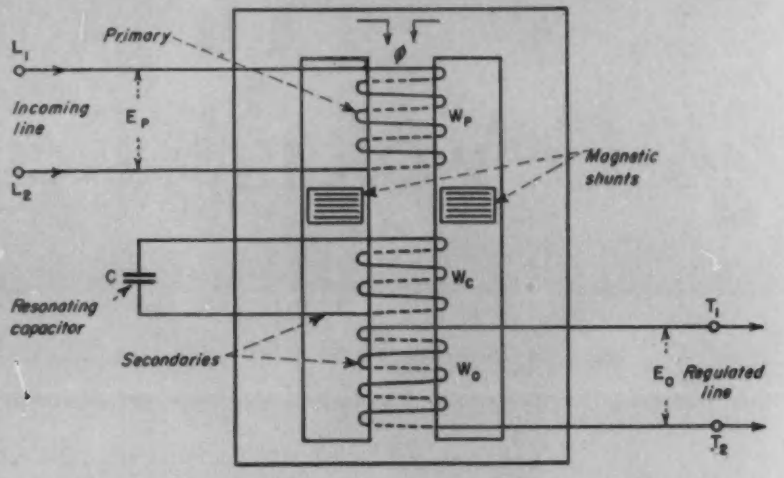


Fig. 2—Basic circuit diagram of a ferromagnetic resonant voltage stabilizing transformer. Capacitor C resonates with leakage reactance of W_o at line frequency. Magnetic shunts bypass portion of secondary a-c flux and maintain flux within secondary portion of core at saturation level. Flux in primary core varies with change in line voltage, but since secondary flux is at saturation level regulated-line voltage E_o remains essentially constant.

INDUCTION VOLTAGE REGULATOR

Induction voltage regulators are similar in construction to the wound-rotor induction motor. A circuit diagram is shown in Fig. 1. In general, the stator or excitation winding is connected directly across the line, and is essentially the transformer primary. The rotor or secondary winding is connected in series with the regulated side of the line. The magnitude and polarity of induced rotor voltages depend upon the direction and angular displacement of the rotor from a null position. The output or regulated-line voltage is obtained by turning the rotor so that induced voltages add to or subtract from the line voltage to maintain the desired value. Induction voltage regulators are frequently arranged for automatic instead of manual operation.

FERROMAGNETIC-RESONANT TRANSFORMER REGULATOR

This type regulator is a device which contains no moving parts and which produces essentially constant regulated voltage with fluctuations in incoming-line voltages. The device is resonant at the line frequency and consequently the regulated voltage varies with frequency, load, and load power factor; but compensating circuits are used to improve regulation. A voltage regulator of this sort produces appreciable waveform distortion because the iron-cored magnetic circuit operates in the region of saturation. When desired, special filters are available to reduce the harmonic content of the regulated voltage.

A basic circuit diagram of the ferromagnetic resonant transformer is shown in Fig. 2. Fluctuating line voltage E_p is connected to primary terminals L_1 and L_2. Current in the primary winding produces an ac magnetic flux ϕ which links with the secondary windings W_c and W_o. The core and windings are so proportioned that within the design voltage range, capacitor C resonates with the leakage reactance of W_o through magnetic coupling to W_c. When resonance exists, the core flux which is encircled by windings W_c and W_o rises to a value sufficient to saturate this core section. Magnetic shunts with air gaps are placed between the center and the outside legs of the main core and between primary winding W_p and secondary W_c and W_o. These magnetic shunts serve to by-pass the secondary flux generated in the section of the core encircled by W_c and W_o; and at resonance a higher value of flux exists in this section. The windings and the core are proportioned so that flux in the core encircled by the secondary windings does not vary appreciably despite flux changes in that portion of the core encircled by the primary windings. The core section associated with the secondary windings remains fully saturated and the constant value of flux through the secondary induces a constant voltage.

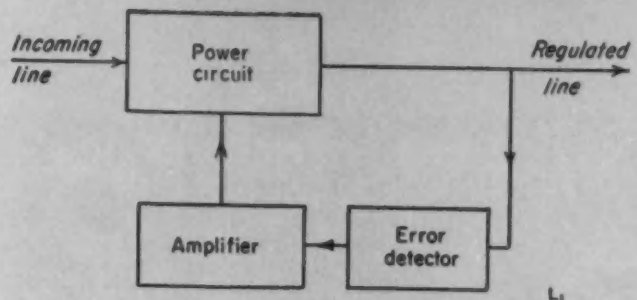


Fig. 3—Basic block diagram of electronically-controlled voltage regulator. Deviation of regulated-line voltage from desired value produces an error signal which is amplified. Output of amplifier is applied to power circuit, producing required compensation.

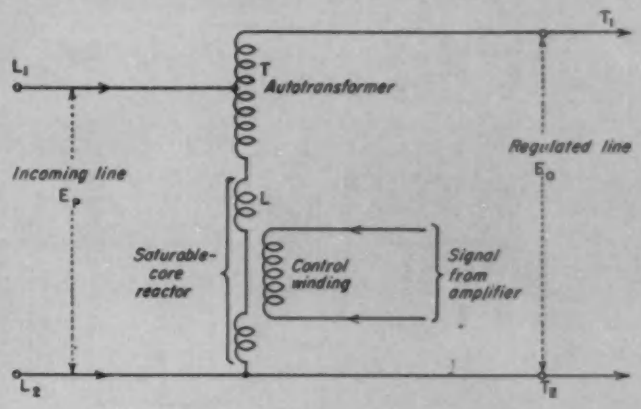


Fig. 4—Elementary circuit diagram of electronic regulator power circuit. Signal from amplifier is applied to control winding of saturable-core reactor, varying reactor impedance and also effective transformation ratio of autotransformer. Variation of transformation ratio is in direction to offset deviation of regulated-line voltage from desired value.

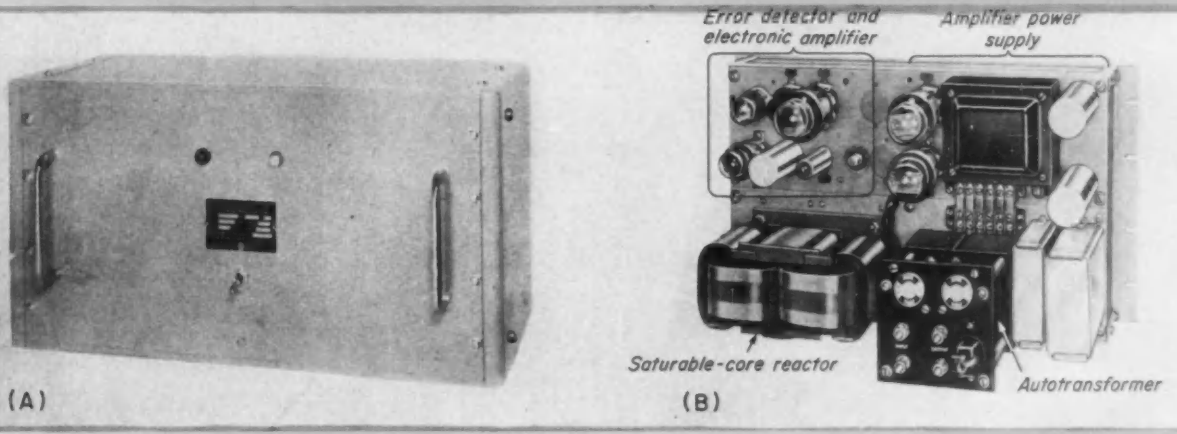


Fig. 5—(A) Front view of 1-kva instantaneous electronic regulator. (B) Rear view of same, showing location of components.

ELECTRONICALLY CONTROLLED REGULATORS

Regulators of the electronic type are instantaneous in response and provide precise regulation up to 0.1 per cent rms. These regulators consist essentially of an error detector, an amplifier, and a power circuit, as shown in the simplified block diagram of Fig. 3. The error detector, which is rms responsive, measures departure of the regulated-line voltage from the desired value and produces a control signal which is amplified. The output of the amplifier is applied to the power circuit, which consists of a saturable-core reactor in combination with an autotransformer as shown in the basic circuit diagram of Fig. 4. The signal from the amplifier is applied to the control winding of the saturable reactor.

In operation regulated-line voltage E_o is equal to incoming-line voltage E_p times the effective transformation ratio of auto-transformer T, which is controlled by the impedance of saturable-core reactor L. The control signal from the error detector and amplifier is applied to the control winding of L. When L is fully saturated by max control signal, the effective transformation ratio of T is approximately equal to the turns ratio, producing max increase of incoming-line voltage E_p. When L is at min saturation and presents max impedance, the effective transformation ratio of T is less than one to one, and the regulated voltage is lower than the incoming voltage. Between the two conditions a continuous variation in the effective transformation ratio of T occurs to maintain a constant output voltage despite variations of both incoming-line voltage and regulated-line load current.

Fig. 5 shows (*A*) the front and (*B*) the rear view of a 1-kva instantaneous electronic voltage regulator. A voltmeter is not supplied with this equipment because regulation of 0.1 per cent rms is beyond the resolving capabilities of the meter. (*B*) shows the saturable-core reactor, autotransformer, error detector and electronic amplifier, and amplifier power supply.

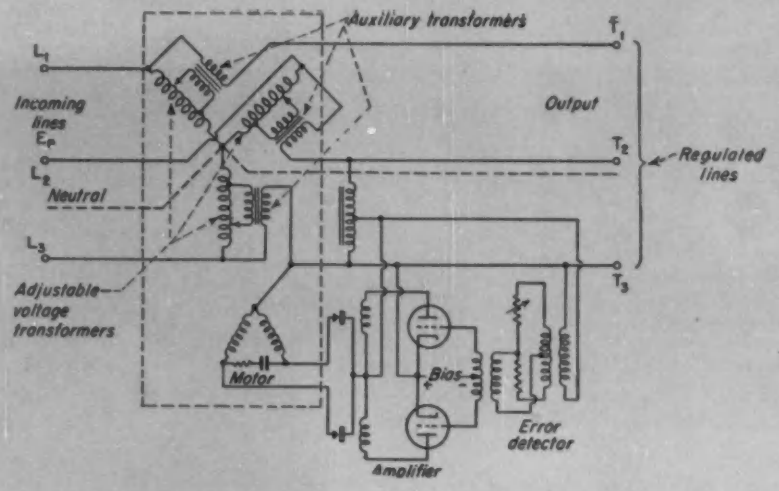
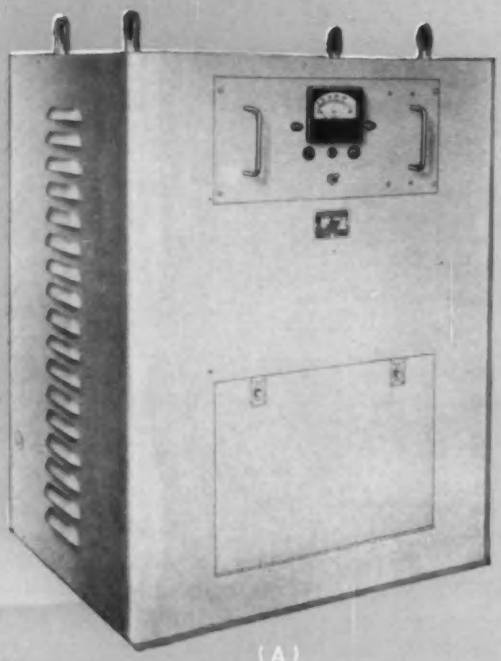


Fig. 6—Simplified circuit diagram of a single-phase, electronically-controlled, electromechanical regulator. Voltage from the regulated-line terminals is applied to an error-detector circuit which produces a signal when regulated voltage varies from desired magnitude. This signal is applied to the amplifier, which actuates the proper motor-control contact. The motor moves the adjustable-transformer arm to increase or decrease the voltage supplied the auxiliary-transformer primary. The voltage across the secondary adds to or subtracts from incoming voltage, depending on required correction.



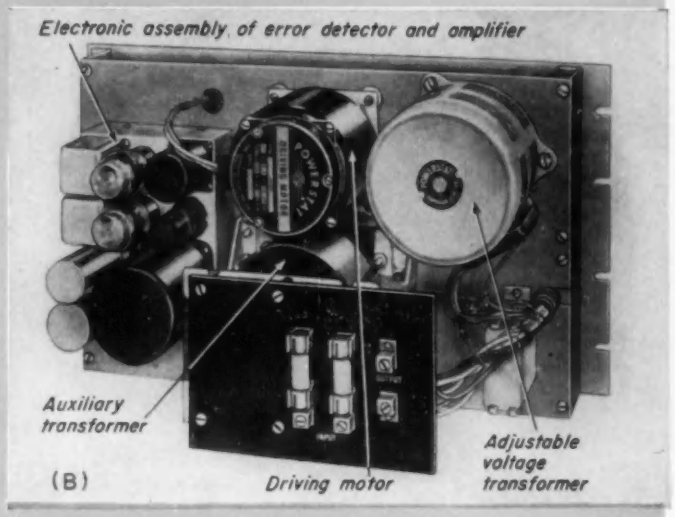


Fig. 7—(A) Front view of 25 kva electromechanical regulator. (B) Rear view of single-phase electromechanical regulator for 115-v line and 2-kva output.

ELECTROMECHANICAL REGULATOR

The electronically-controlled electromechanical regulator will satisfy the greatest number of requirements since it is suited to loads of 2 kva to 100 kva and provides regulation of approximately one per cent. This rating is based on the total kva which the regulators can supply at their terminals, and not the corrective kva rating used by NEMA. The block diagram of Fig. 3 also applies to this regulator, which contains an error detector, an amplifier, and a power circuit. The essential difference lies in the power circuit, which consists of a motor-driven adjustable-voltage transformer and auxiliary-transformer combination.

A simplified circuit diagram of a single-phase electromechanical regulator appears in Fig. 6. The voltage-sensing element, or error detector, consists of a bridge with a current and temperature-sensitive resistor. The bridge receives a voltage from the regulated-line output, and at the controlled-value voltage the bridge is in balance and error signal is zero. Regulated-line voltages above or below the desired value vary the resistance of the nonlinear element, unbalance the bridge, and produce a control signal.

The control signal is applied to the amplifier, closing one of the motor control contacts. The motor turns the

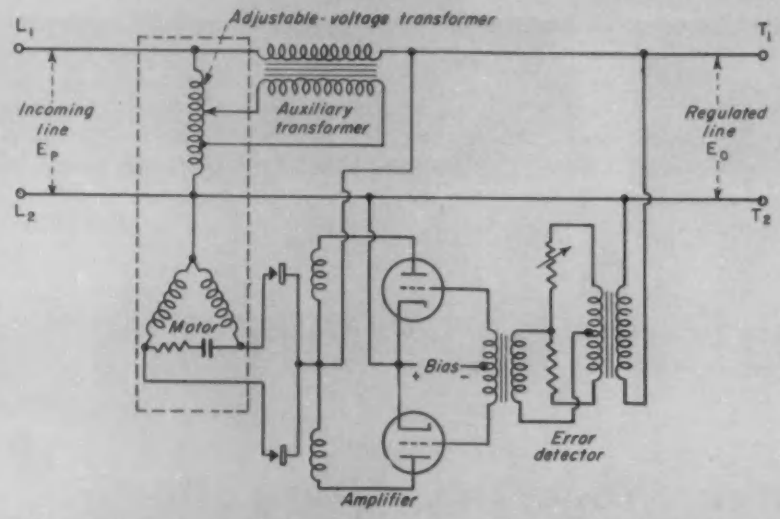


Fig. 8—Simplified circuit diagram of three-phase electromechanical regulator. Regulated voltage of three phases is controlled by regulation demands of single phase. Additional control components to provide individual-phase regulation can be added.

Table I

TYPE	ADVANTAGES	DISADVANTAGES	PRINCIPAL USE
Induction	No sliding contacts carrying current Can withstand heavy overloads	In small sizes it is costly per kva Has appreciable internal impedance and produces harmonic distortion of line voltage	100 kva and larger loads for group of users or central distribution area
Ferromagnetic resonant transformer	No moving parts Rapid response Economical in small sizes	Output varies with change in load or power factor, unless compensating circuits are added Produces 10 to 20 per cent harmonic distortion unless filter networks are added Frequency sensitive	For small, constant loads, where line frequency is fixed, and where harmonic distortion of output voltage is acceptable
Electronically controlled saturable core reactor	No moving parts Rapid response Produces negligible harmonic distortion of line voltage Provides precise regulation to 0.1 per cent rms	Costly per KVA	Industrial X-ray Computers
Electronically controlled adjustable-voltage transformer	Low cost per kva Simple construction Adaptable to special electrical ratings	Contains moving parts	For 2 to 100-kva loads where 1 per cent accuracy will suffice

movable arm of the adjustable transformer to either increase or decrease the voltage supplied the auxiliary transformer primary, depending upon the required voltage correction. Since the auxiliary-transformer secondary is connected in series with the line, the regulated-line voltage is equal to the algebraic sum of the incoming-line voltage plus the auxiliary-transformer secondary voltage. The output voltage is thus maintained constant by correction obtained from the auxiliary transformer secondary. The rear view of a single-phase electromechanical regulator rated for a nominal 115-v line and 2-kva output is shown in (*B*) of Fig. 7. This unit is made for mounting in a standard relay rack. (A) is a front view of a 25-kva unit.

Fig. 8 is a simplified circuit diagram of a three-phase electromechanical regulator which has three regulated power circuits but is otherwise similar to the single-phase regulator. In this equipment a single control circuit, which can be connected to receive a control signal from any one of the three phases, is employed. This type of unit simultaneously regulates voltages of the three phases in accord with the control signal derived from the selected phase. In most applications both input-line voltages and loads are sufficiently balanced to make this type of control satisfactory. Where individual-phase control is required additional control components can be readily added to the unit.

REGULATOR SELECTION. Table I may be used as a guide in determining the proper regulator to use for a specific application. In general, the electromechanical adjustable-voltage transformer regulator will provide the answer to the majority of regulator problems. Where precise control is required, the more costly electronically-controlled saturable-core reactor type must be used. For small, constant loads, such as with instruments or electronic equipment, the ferromagnetic resonant transformer may readily be incorporated as a component part.

A specific application of the electromechanical type regulator is in the testing of fractional horsepower motors for varied appliances.

An application example in the use of electronically controlled regulators is with X-ray equipment. Because X-ray emission is proportional to a high exponential power of the voltage it is necessary to maintain the voltage within precise limits in order to provide adequate control of the emission. Only the electronically-controlled type suffices.

EDITOR'S NOTE: This article is the first in a series presenting information concerning the selection and application of voltage regulating and voltage-control devices. Forthcoming articles will present detailed data and considerations involved in integrating voltage regulators and controls into equipment design.

Foamed Isocyanates

Formation, properties, applications

Versatile new plastics have excellent thermal insulation properties, high strength with low density and resistance to moisture. Foams are available in two forms: resilient to semi-rigid and rigid, and flexible, both in a wide range of densities.

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THE SIGNIFICANT PROPERTY of polyisocyanate to liberate carbon dioxide while polymerizing has led to the development of a wide range of new plastic foams. Expansible polyisocyanate resins are usually prepared by the reaction of an excess of polyisocyanate with a polyol or a polyester compound. Polyurethane thus prepared can be reacted with water or additional polyester, containing unreacted carboxyl groups, to liberate carbon dioxide. Simultaneously, further polymerization and cross-linking take place and in so doing entrap the liberated carbon dioxide.

These polyisocyanate foams have been used as thermal insulation, potting compounds for electronic equipment, buoyancy gear, packaging protection, and automotive parts. The use of these foams is limited only by the ability of the chemist to produce new formulations.

Methods of Application

Isocyanate foams are prepared from two component liquid systems and are easily mixed prior to application. Once the two components are mixed they have a short pot life and therefore must be poured immediately into the cavity. The technique used to bring about the mixing depends upon the type of application. For those which are intermittent and fairly small, batch mixing is by far the most simple to use since up to 10 lb of the liquids can be mixed and poured by hand. Continuous mixers have been developed to handle larger quantities of foam for use in items which lend themselves to mass production techniques.

In some instances, it has been found desirable to spray the material. Spraying apparatus is available which will apply the foaming material over a wide area at the rate of 3 to 4 sq ft per minute. This type of application is especially useful where the foam is being used for thermal insulation, as a condensation barrier or sound deadening agent.

The mixed liquids spontaneously expand after being poured or sprayed, to fill a cavity or cover a surface. During foaming, the resin expands to fill the shape of a container and three distinct phases can be observed:

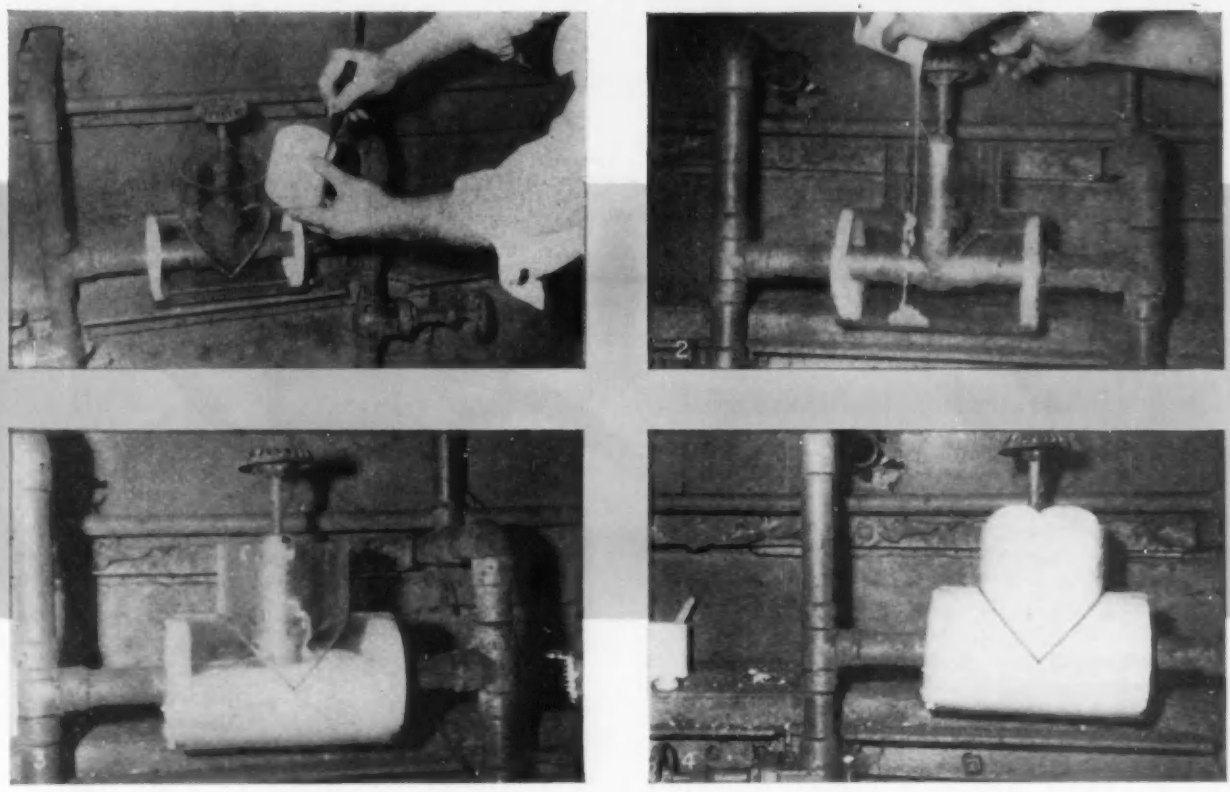
(a) A sharp decrease in the viscosity of the mixed material occurs immediately after pouring. At this point, the foaming liquid will seek out and fill the most intricate void.

(b) As the foam continues to rise, the viscosity increases rapidly to a gel-like state. At this stage, it is more difficult for the foam to reach all the complex voids within the mold. This limitation can be overcome by the use of multiple small pours, the selection of the pouring site for the mixed liquids, or in the fundamental design of the mold.

(c) The final phase is the curing of the plastic foam.

During foaming, reaction heat is liberated to bring about self-curing of the plastic foam. To obtain the maximum strength with some formulations, additional curing is necessary. Even without this additional curing period, maximum physical properties are not obtainable until the foam has aged for at least 24 hours.

Polyisocyanate foams, in general, exhibit excellent adhe-



Polyisocyanate flexible foams could, by utilization of the advantages of being foamed in place, simpler processing, reduced labor costs, and improved properties lead to the simplification of some design problems.

sion to surfaces such as metals, wood, glass fiber laminates, fabrics, glass, and most plastics. In most instances, failure of the bond will occur within the first layer of foam adjacent to the substrate rather than at the bonding site. It has been found that with certain formulations it is advantageous to precoat the surface in contact with the foam with certain primers to obtain high bonding strength. To utilize these adhesive properties to their fullest extent, the bonding surface must be clean. Tetrafluoroethylene and polyethylene are non-bonding surfaces. Molds lined with these materials have been found to be satisfactory for use in applications where it is desirable to remove the finished foam. For metal and plastic casting, ordinary paste wax can serve as a mold release agent.

There are hundreds of polyesters and polyols available which react readily with polyisocyanates. By varying the polyisocyanate ratios in these reactions, virtually an infinite number of formulations can be produced with a wide variety of properties. Thus it is possible to chemically build a foam for a specific end use.

By the use of oil-soluble dyes, these foams can be colored the full width of the visible spectrum. Bright and varied colors present definite sales appeal for commercial markets; industrial fields find this colorability an added advantage for coding.

Types of Polyisocyanate Foams

In discussing the specific properties of these plastic foams, they can be divided into two categories: (1) Resilient to semi-rigid and rigid foams ranging in density from two to 35 lb per cu ft; and (2) Flexible foams in a wide range of densities with varying properties.

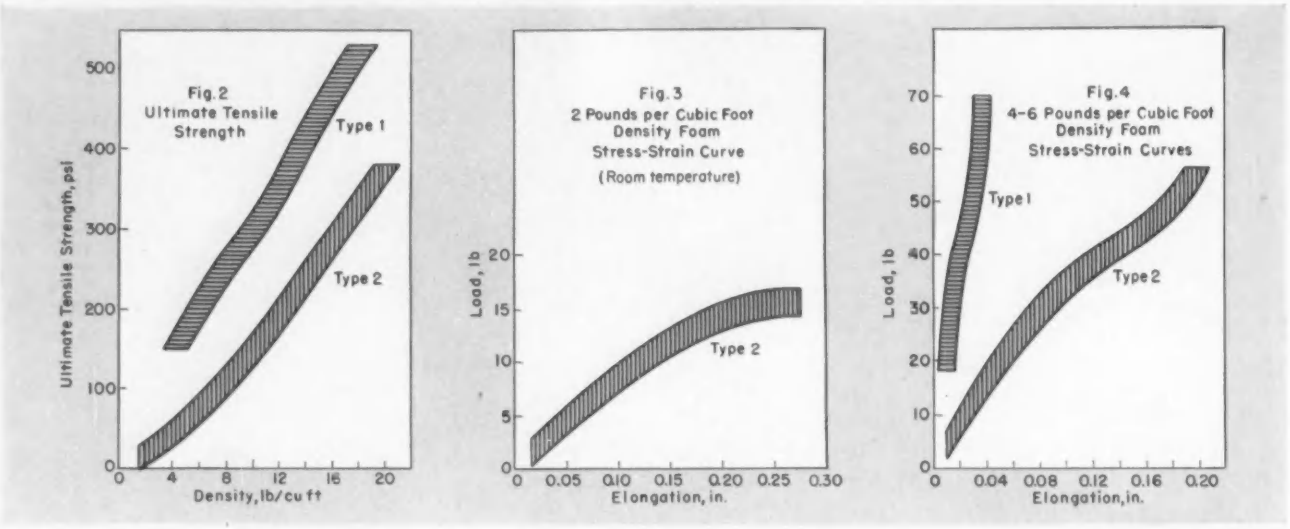
There are two types of resilient-to-rigid foams on the market. Type-1 is an alkyd resindiisocyanate. The production of foam from this type of material is accomplished by the mixing of one component containing the resin and catalyst with another component containing the diisocyanate. Formulations in a variety of densities are available. each with different properties. Most of the formulations based on the above materials require some degree of aftercure to obtain the maximum physical properties.

The Type-2 foam in this classification is based once again on a two-component system. However, the base material and diisocyanate have previously been reacted by the manufacturer to produce what is known as a prepolymer. This single component is then mixed with a small amount of the catalyst solution (second component) to produce a foam. With this type, only the catalyst solution is varied to produce different density foams from the same prepolymer. Foams produced by this system are self-curing.

Properties of Semi-Rigid to Rigid Foams

Moisture Resistance: The semi-rigid to rigid foams is essentially a network of cells. For this reason, the water absorption is quite low, decreasing as the density increases. Where a protective skin completely surrounds the foam, such as when the foam has been molded, water absorption is extremely low.

Thermal Insulation: The insulating capacity of a 2-lb density resilient foam (TYPE-2) is shown by the data



given in Fig. 1. Since plastic foams are formed by the entrapment of gas into millions of small cells, the thermal conductivity of such a product is very low, and its thermal insulation properties very desirable. This fact, in conjunction with the low thermal coefficient of expansion indicates that gross changes in temperature will not affect the structure of the foam. The linear thermal coefficient of expansion (determined according to ASTM Specifications D696-44) in the temperature range −30 to +30 C for a density of 2 lb/cu ft is 2.48×10^{-5} in./in./C and is 9.25×10^{-5} in./in./C for density of 16 lb/cu ft.

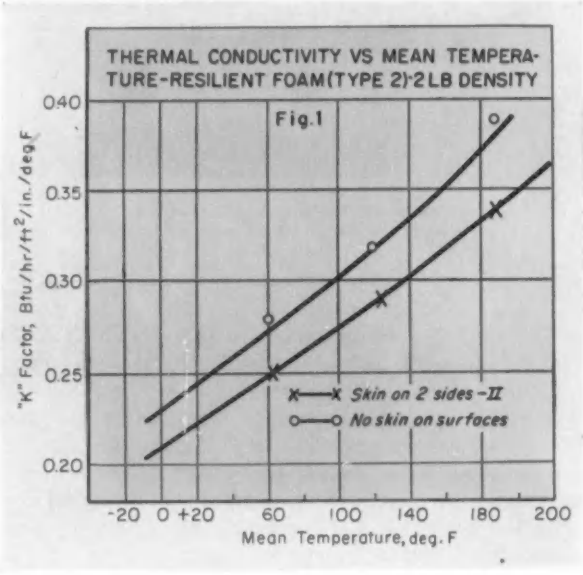
Mechanical Properties: Ultimate tensile strengths of the two types of foams are shown in Fig. 2. This graph indicates that the Type-1 material offers higher tensile strength than the Type-2 material at the same density. This can be explained by the fact that in Type 1 higher exotherm temperatures are present during the foaming action and a post-cure is utilized. Both of these conditions lead to additional cross-linking and higher tensile strength. This theory is further supported by the stress-strain curves of Figs. 4, 5, and 6 which indicates a higher per cent elongation for the Type-2 material. Both of these properties are important to the selection of the proper material for a specific application.

Electrical Properties: These plastic foams are available with a wide range of electrical properties. The dielectric constant can range from 1.04 to 2.69. The figures vary depending upon the frequency used, density of the foam and its formulation. The power factor is in the range of 0.002 to 0.003.

Oil Resistance: The polyisocyanate foams are resistant to oils, greases, petroleum products, gasoline, and aromatic solvents.

Vibration Resistance: The high strength-to-density ratio of the polyisocyanate foams, coupled with their excellent adhesive properties and non-friability, enable the foam to withstand intense vibrations without failing.

Flame Resistance: Most of the polyisocyanate foams tend to melt and run from the flame, rather than burn. Those


THERMAL CONDUCTIVITY VS MEAN TEMPERATURE-RESILIENT FOAM(TYPE 2)-2 LB DENSITY
Fig. 1
"K" Factor, Btu/hr/ft²/in./deg F
Skin on 2 sides -II
No skin on surfaces
Mean Temperature, deg. F

foams that do burn can be formulated with chemical retardents to improve their resistance to flammability.

Some or all of the properties of the semi-rigid to rigid plastic foams indicate their applicability in a wide variety of uses. Batch mixing as well as the continuous mixing and spraying devices open new methods of production techniques which could result in savings in labor costs.

Because of their excellent thermal insulation properties plus resistance to moisture and mold, polyisocyanate foams are useful for insulating home freezers, refrigerators, water coolers, refrigerated trucks and railroad cars, and other refrigerated units. With their good insulating values and ease of application, industrial plants will find them of interest in covering low temperature lines, low pressure steam lines, and valve clusters located in relatively inaccessible places.

The high strength with low density, thermal insulation, and acoustical properties can be used to great advantage in sandwich construction for prefabricated building panels of all types.

The strength and electrical properties can be effectively

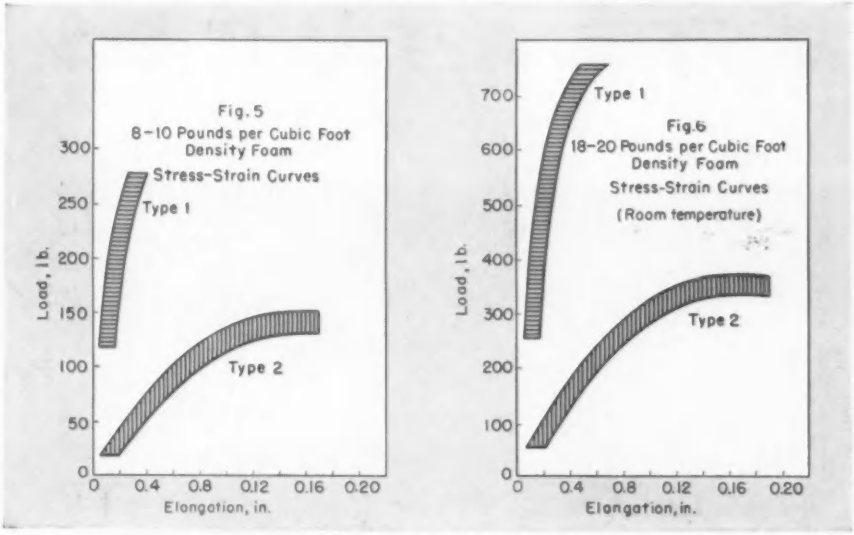


Table I—Typical Properties of Various Polyester-Polyisocyanate Elastomeric Foams

	A	B	C	D	E
Density	3.8	4.3	4.3	4.5	4.3
Tensile, psi	24.0	14.5	14.0	31.0	4.0
Elongation, per cent	200	375	196	140	60
Compression Deflection, psi for 25 per cent	0.42	0.6	0.8	1.3	0.4
Compression Set 50 per cent compression for 22 hr at 25 C	1.6	9.0	13.0	4.5	25.0
Water Swell, per cent weight increase in 24 hr at 200 C	0	2	3.4	4.0	3.0
Solvent Swell, per cent weight increase in 24 hr at 25 C in SR-10	2.4	12.6	0.9	18.6	18.6

utilized as a core material for radomes in aircraft and guided missiles. These same properties can also be used to provide space saving through potting of radio and other electronic circuits.

Plastic foams can be used in most types of buoyancy and flotation gear. With articles subject to constant immersion in water, an additional thin coat of paint or cover of plastic would provide extra protection.

Flexible Foams

The flexible type of polyisocyanate foamed plastic is based on the reaction product of a polyester with a diisocyanate. These foams are mainly of the open cell type, although it is possible to make an elastomeric-like foam with closed cells by the use of blowing agents coupled with heat and pressure. As with the semi-rigid and rigid type foam there is a multiplicity of combinations possible. Depending on the specific polyester and diisocyanate used, a host of foamed polymers can be made. These polymers vary from hard, brittle and high density materials to soft, flexible and low density products.

The reaction product of the polyester and diisocyanate gives extremely long-chain molecules. These long-chain molecules can then be further modified by the selection of the cross-linking agent. When water is used as such an agent and allowed to react with an excess of diisocyanate present in the long-chain molecule, carbon dioxide is liberated. Thus, as with the other type of foams mentioned above, the carbon dioxide becomes entrapped during the cross-linking or curing cycle to produce a plastic foam. Depending on the rate of this cross-linking, spheres of gas are entrapped by the resin, producing cells which can range from the size of a pinpoint to ¼-inch.

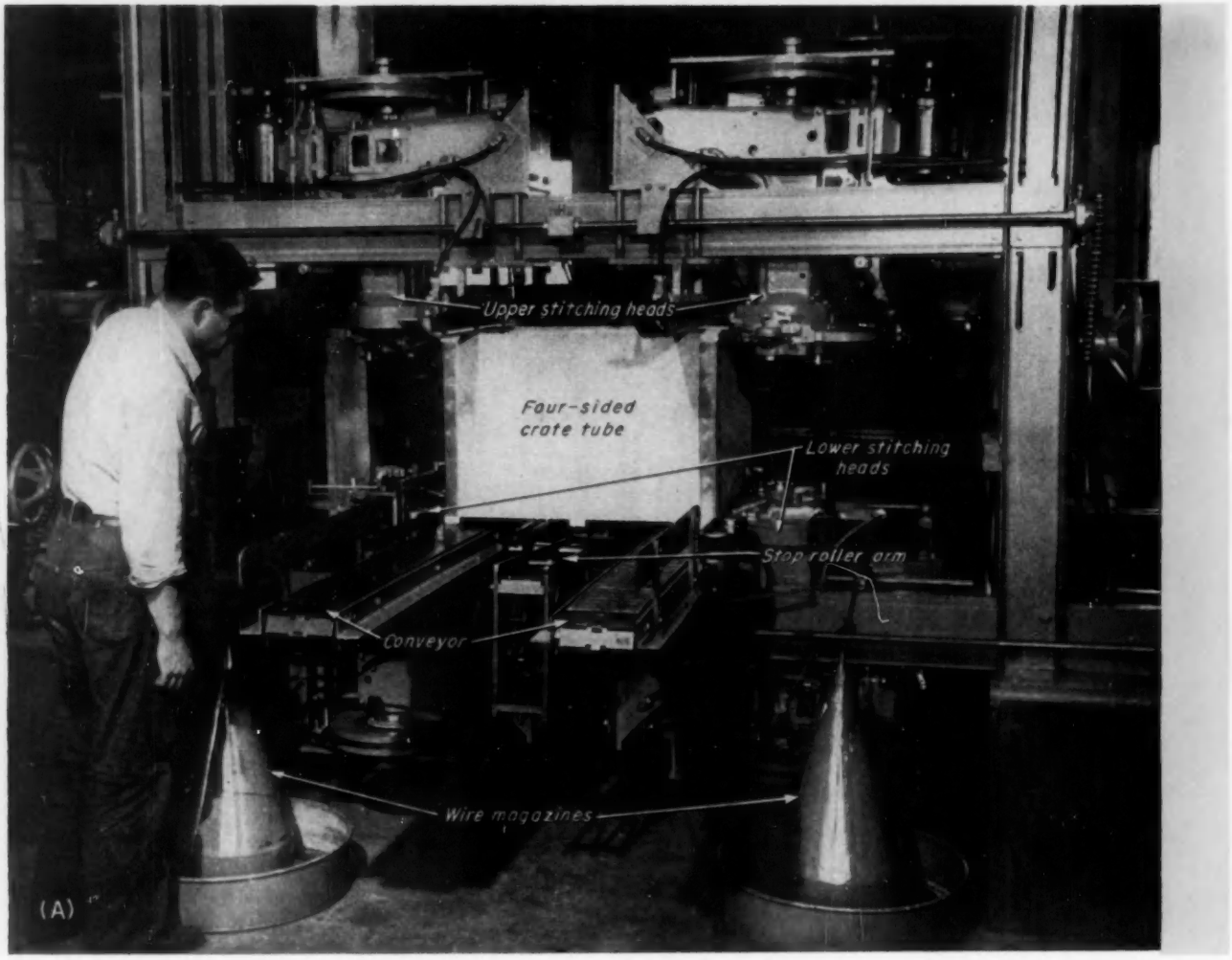
In general, these flexible foams exhibit good aging properties, are resistant to common solvents, such as naphtha and benzene, and are odor free. Their open and interconnecting cell structure enables the foam to breathe and also to hold water as in a sponge. These foams can be applied by the same methods as shown for the semi-rigid and rigid type; they are usually self-curing.

A comparison of the physical properties of various polyester-diisocyanate foams is given in Table I. It will be noted that various formulations produce high compression with low density or low compression with low density. The prospective uses of these foams follow the paths already established by latex and vinyl foams.

As with many chemicals, the diisocyanates offer a problem in safety. Tests have shown that diisocyantes in general are toxic upon continuous inhalation of their vapors and care should be exercised in their use. However, with the use of adequate and proper ventilation, aids for the prevention of skin contact, this hazard should offer no obstacle to the fullest utilization of this very reactive and useful family of chemicals.

As is usually the way with most new products, limitations exist because of the present state of development. Polyisocyanate foams are relatively expensive at this time thus making them economically unsuitable for many applications for which they are technically feasible. Several large chemical companies have indicated increased production schedules for diisocyanates in the near future, which should overcome this disadvantage. As the polyester and isocyanate chemists widen their knowledge and experience in the field, present products will be perfected and new uses forthcoming.

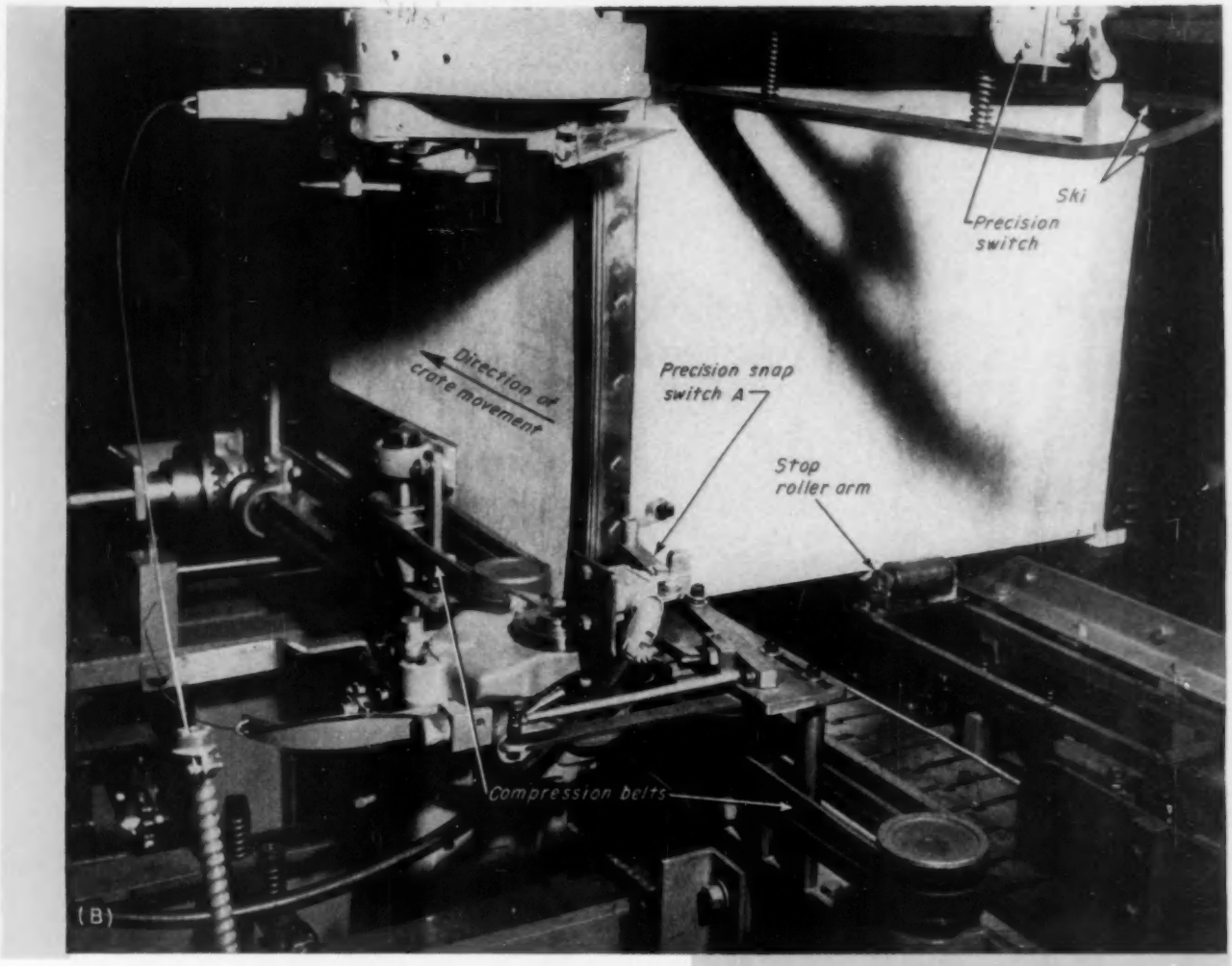
DESIGN FEATURES



Stitcher Heads Speed Plywood

The need for an inexpensive rapidly assembled shipping container led to the development by Atlas Plywood Corporation of the Ply-Fold crate which consists of a plywood base, top and four-sided tube. The latter has fiber board or metal seams that permit it to lie flat. This design does away with side cleats, reduces the number of parts to three and cuts storage space appreciably.

To speed up assembly of crate around product being shipped, Atlas teamed up with Bostitch in the design of the Ply-Fold Assembler. This is a twin-machine unit—one machine fastening two sides (top and bottom) simultaneously, then revolving the crate on a turntable to the other machine which repeats the operation on the remaining sides. Two standard Bostitch steel stitcher heads at the top of each machine staple the top of the crate to the side, and two additional heads at the bottom staple the bottom to the side. Positioning of the 16-gage staples is determined by the nature of the shipment. This is easily effected because the intermittent drive of the conveyor which carries crates through the Assembler is positive and adjustable. An automatic "electric brain" locates the first staple and places the succeeding staples in the exact location de-



Crate Assembly

sired—any distance between 3 and 10 in. apart and in from top and bottom edges. Staples are easily removable with claw hammer, screw driver or staple puller.

Fitting directly into a production line, the assembly does not require belting, gearing or connection other than location.

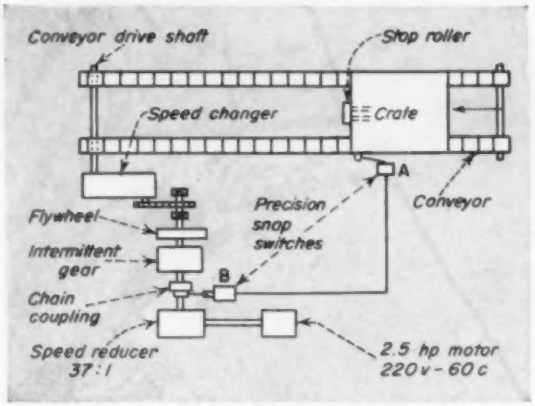
The main problems faced in designing the Assembler were to control the position of the crate on the conveyor for proper location of staples and to synchronize the four stitcher heads with the intermittent movement of the conveyor.

(A) Each of the two Assemblers drives four staples into the plywood crate simultaneously. Crate is shown in position for receiving last set of staples on top and bottom edges of two opposite sides. Previous sets of staples have been driven according to spacing determined by intermittent and regular movements of the conveyor. Two of four wire supply spools are shown with wires engaged in stitching heads.

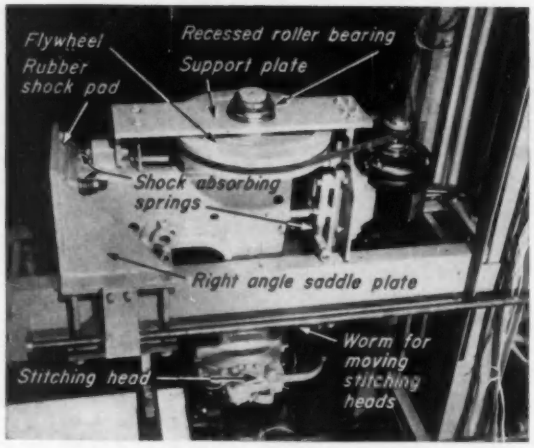
(B) Crate has just finished second half of stapling cycle (first-half-cycle staples visible along lower edge of crate). Stop roller arm moves upward, de-energizing system until another crate is conveyed into position. Incoming crate pushes arm on switch A which energizes conveyor intermittent drive system and, in turn, the firing solenoids in stitching heads. Conveyor advances crate until its bottom leading edge contacts stop roller, establishing position for driving first set of staples.

(Continued on next page)

Plywood Crate Assembly (continued)



CONVEYOR POWER and control "package" can be positioned conveniently within chain distance of conveyor drive shaft. Switch *B* which energizes solenoids in the four stitching heads is actuated by arm mounted on coupling housing, ie, a set of four staples is driven into the crate once per revolution of the speed reducer output shaft. This same shaft motion is fed into the intermittent gear assembly. The setting of the adjustable sleeves in the Reeves speed changer determines the ratio of intermittency between the intermittent gear output shaft and the conveyor drive shaft. Calibration of the speed changer settings in terms of linear movement of the conveyor makes it a simple matter to achieve a desired spacing of the staples which are driven during the dwell periods of the conveyor.

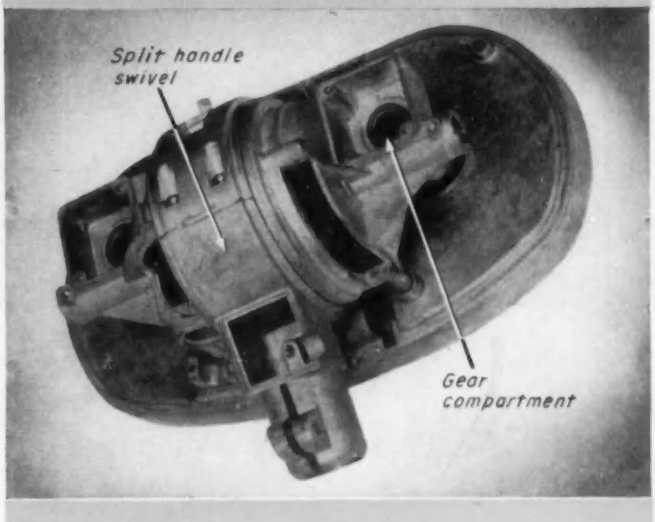


STANDARD BOSTITCH heads are designed for vertical driving of the staples. In the Ply-Fold Assembler, however, all four heads must drive staples in horizontal planes. This means they had to be mounted on right-angle saddle plates and, most important of all, necessitated positive control of the weight loads and driving thrusts. To support the 50-lb heads with their individual flywheels, roller bearings were used on the outboard end of the flywheel shafts. For the two upper stitching heads, as shown, the bearing is recessed into the anti-flywheel side of the support plate; for the two lower heads, the bearing is again recessed but in the flywheel side of the support plate. The rubber pad and coil springs isolate thrust loads from the machine proper.

Zinc Die Castings

In achieving a simple yet functional high-quality design in their polisher-scrubbers, the Regina Corporation of Rahway, N. J. reversed common procedure. Instead of developing the design and then specifying material and fabricating method, they decided to use zinc die castings and designed the principal non-electrical components to take advantage of the wide latitude inherent to the process.

In minimizing the number of components, interrelated parts were combined into unitary construction. This precluded the need for many parts which would otherwise increase metal consumption during machining and add to the weight, bulk and over-all complexity of the final assembly. Optimum distribution of weight, balance and a low center of gravity were needed to insure maximum efficiency and ease of operation. Sections were varied to fit changes in stress pat-



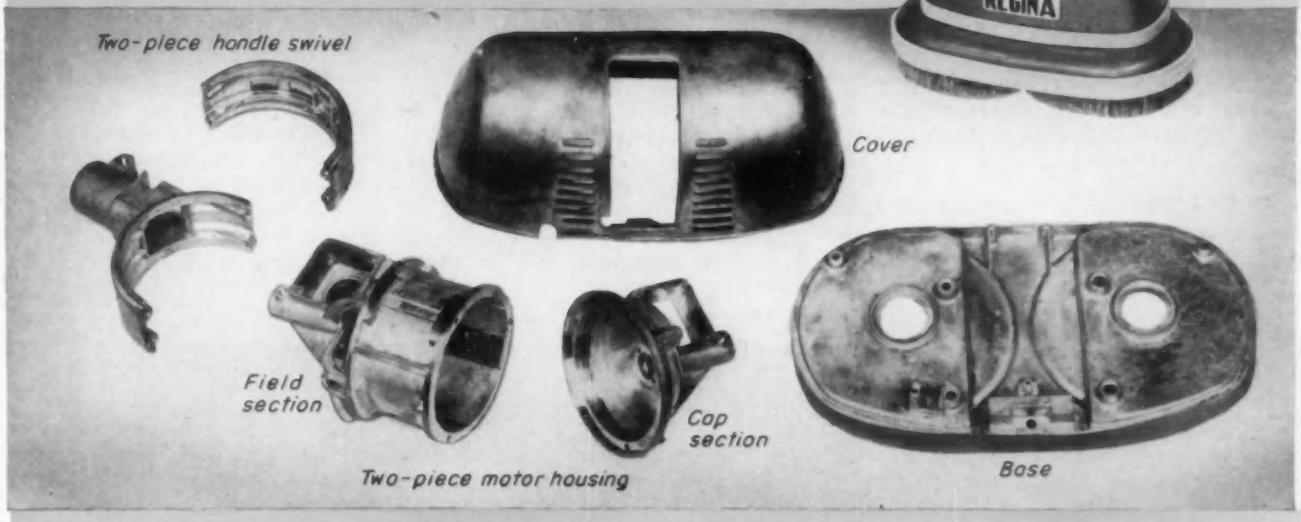
BASIC DIE CAST PARTS INCLUDE: a two-piece motor housing, split handle swivel, base, and cover. The design of these six components embodies all the production of non-essential projections. The cap and field typifies the planning and engineering which have gone into the polisher. The motor housing consists of two intricate castings designed as simple in shape as the important requirements of the parts permit; this includes the elimination of non-essential projections. The cap and field sections are built to provide torsional stability with walls as uniform as possible, but held to low limits to keep

Basis of Polisher Design

terns and to insure highest strength-weight ratio. Where stress is greatest, sections are thick, but held to lowest practical limits; in areas of low stress, sections are thin to reduce unnecessary weight. Effort was made to avoid wide variations in sectional thickness which might restrict metal flow during the casting operation.

Maximum use was made of dowel-forming tubular projections to keep assembly costs low and prevent loosening during service. Full use was made of the great latitude zinc offers in depth of cores and minimum diameters that can be cast. Holes and tubular sections are formed by cores held to a degree of accuracy such that only reaming is necessary to give proper alignment.

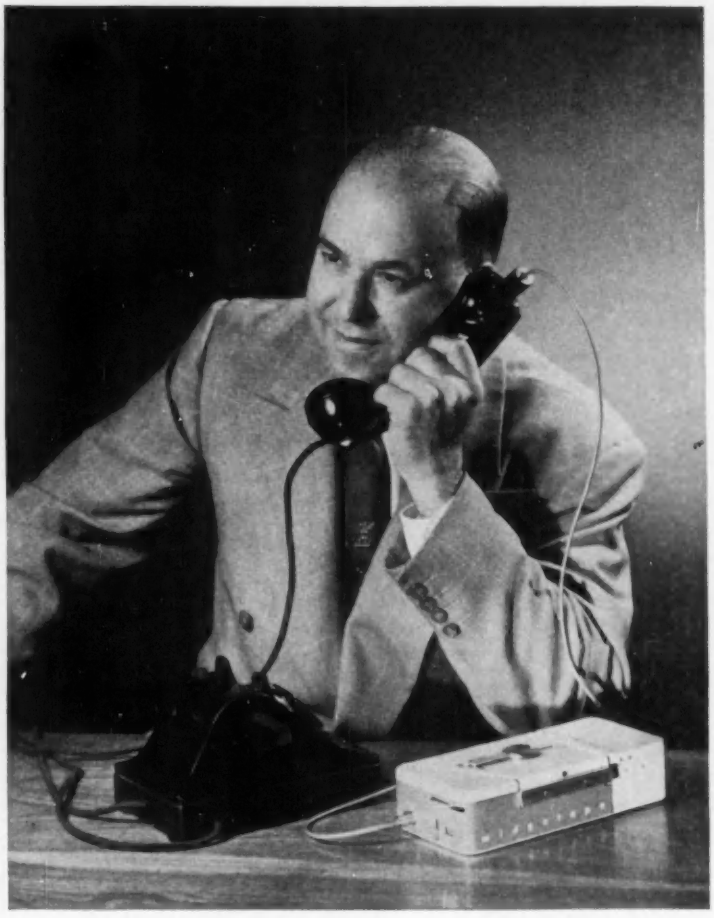
Several models of twin-brush polishers have been adapted for assembly from the same type of zinc die castings. Large model at right is for extra heavy duty service.



weight down. Cast-in pole pieces insure exact positioning with respect to the field and armature assemblies and thus contribute to long-term peak motor performance. Built into the cap and field sections are compartments for gear mesh of motor output shaft and verticle brush spindles. Ribs and supports are located at stress areas to take advantage of the high strength characteristics of their sections. The base is hollowed and channeled underneath to reduce weight. Bosses accommodate lead wire, and attachment to motor housing and cover. Ribs rightly sized and positioned afford adequate strength for rough use expected. The cover is made with variations in form and sharpness of modeling not possible with sheet metal or sand casting. Perfectly blended contours for functional and decorative purposes were included in the cover design. The swivel is made up of two die castings, one of which has a cored tubular section to accommodate the handle. The two parts are designed so that when mounted and assembled around the motor housing, perfect sliding fit allows easy rotation for maneuvering the handle in service. The self-lubricating and rust-free qualities of zinc preclude freezing and sticking at contacting areas.

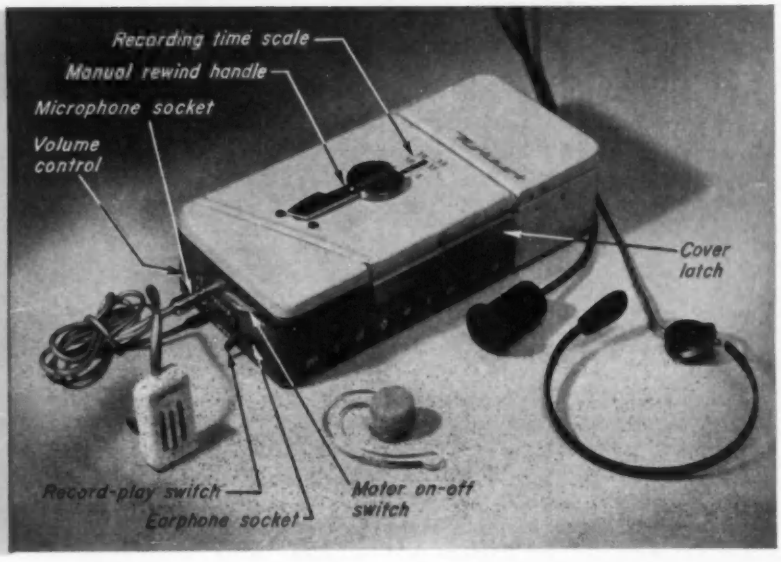
Miniaturization Secret of Midget Tape Recorder

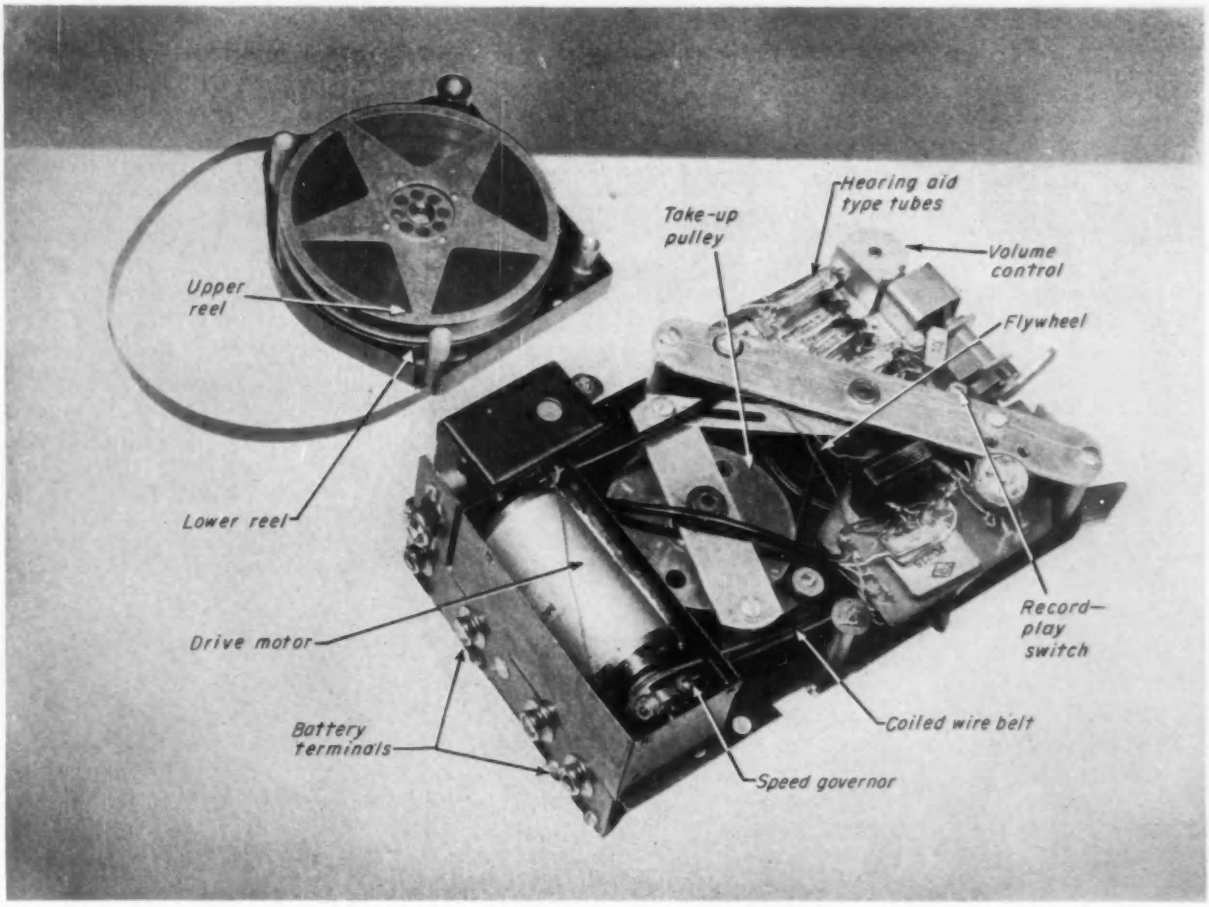
Applying some of the proven techniques used by the hearing aid manufacturers, the Mohawk Business Machines Corporation of Brooklyn, N. Y., have designed a small tape recorder which weighs just over three pounds and measures only $8\frac{1}{2}$ by $3\frac{7}{8}$ by $1\frac{7}{8}$ in. Powered by a 30 v "B" battery and an 8-cell mercury battery pack, the Midgetape has a twin-track cartridge containing sufficient $\frac{1}{4}$ in. iron oxide plastic tape for a half-hour recording on each track. A 0.003 hp, 7-v d-c motor drives the tape at $1\frac{7}{8}$ in. per sec from one reel through the recording head and winds it on the second reel. Rewind prior to playback is manual. Adaptable to its own carrying case or for incorporation into a brief case, the recorder has high sensitivity, permitting lifelike reproductions through a standard throat or lapel microphone, and also from a suction-cup induction coil pickup attached to a telephone receiver.



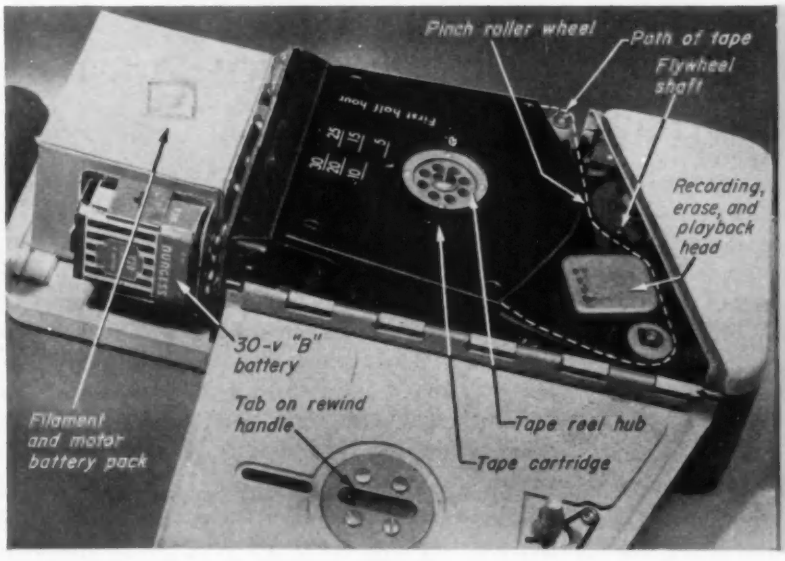
SENSITIVITY of midget recorder is demonstrated by the fact that the induction coil pickup can be attached to headpiece or on main body of telephone receiver. Half-hour conversation can be played back, following manual rewind, through 110 v a-c amplifier or earphones. Light on case tells when motor battery has four hours life. "B" battery for amplifier has life of about 100 hr; 8-cell mercury battery—one cell (1.35v) for tube filaments and seven in series (9.2v) for motor—lasts 45 hr.

PICKUPS include various types of microphone which plug into end of case as illustrated. Rewind handle is pulled out, flipped over and rotated prior to playback. Multi-function controls at end of case simplify manipulation when recorder is positioned upright as in a brief case, for example. Scale on top of case indicates consumption of tape in minutes and permits noting approximate beginning and end points on tape for any specific recorded sequence.

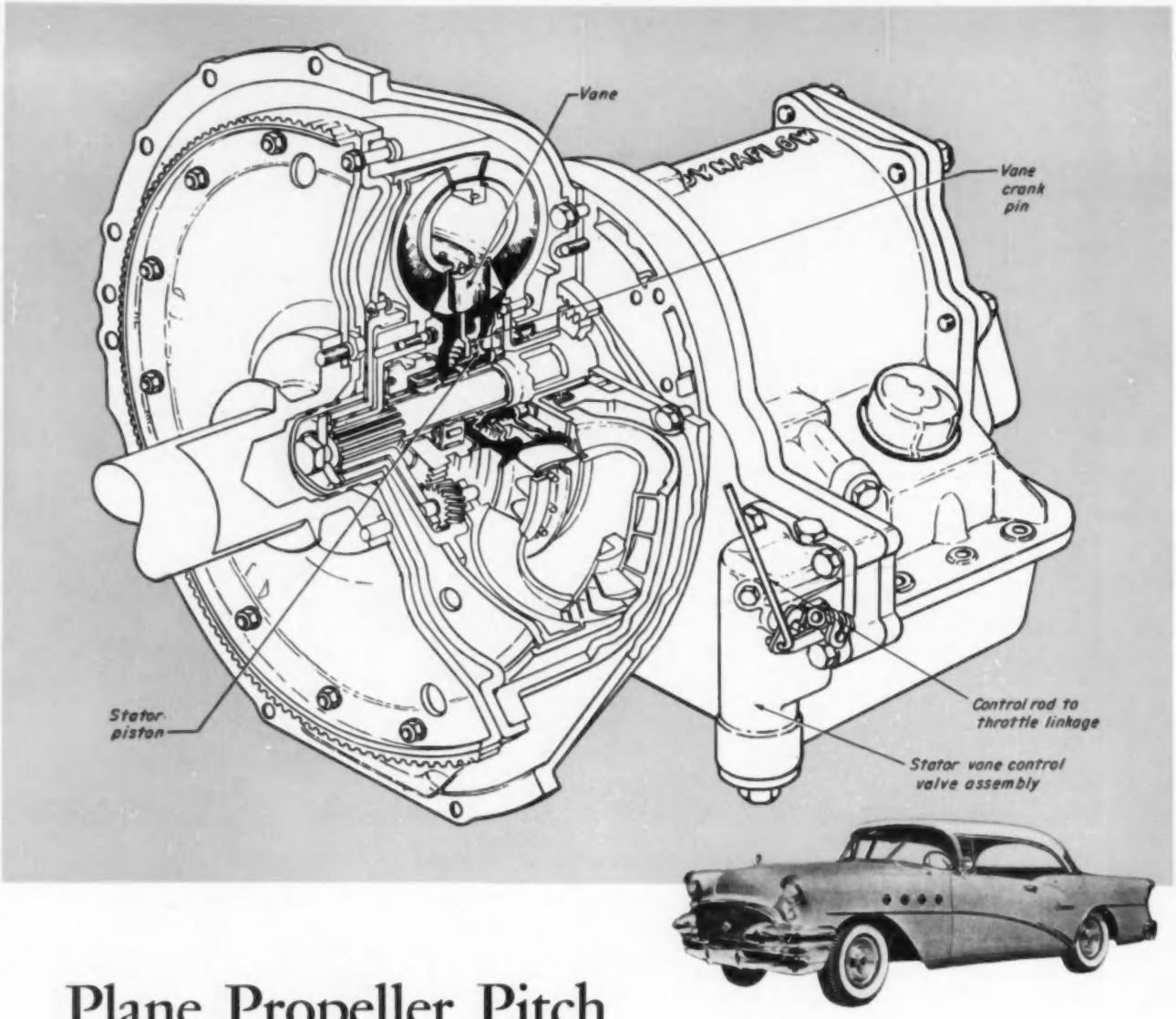




BOTTOM VIEW of main chassis shows compact grouping of electronic and mechanical components. Motor drives flywheel through spiral spring belt. Flywheel shaft extends through chassis so that, when pinch roller wheel is spring loaded against it, the intervening tape is driven by rotation of shaft. Loose tape is then picked up by bottom cartridge reel which is revolved by take-up pulley keyed to bottom reel hub. Take-up hub is loosely coupled by belt to flywheel so that it always exerts tension on tape to be reeled in. Motor speed is controlled by an electro-mechanical governor. Three tube complement has high impedance input—1 mv minimum. Frequency response of 200 to 4000 cps. Wow and flutter are designated as less than 0.7 per cent. Output is 3 milliwatts at 2000 ohms, with signal-to-noise ratio of 35 db and overall gain of 70 db.



TAPE CARTRIDGE is simple to install and remove. Pinch roller wheel is shown engaged against flywheel shaft with tape between. When wheel is retracted, tape loop is easily threaded along path indicated by dashed line. After a half hour of recording, cartridge can be turned over and a second 30-min transcription made. When cover is closed, tab on rewind handle engages a hole in the tape reel hub making rewinding possible when handle is flipped over. Rewind mechanism has one-direction handle rotation.



Plane Propeller Pitch Changer in Buick Dynaflow Transmission

One principal engineering change in the 1955 Buicks is the redesign of the twin turbine Dynaflow transmission to incorporate a stator assembly having variable pitch vanes instead of fixed vanes. This modification makes it possible to operate the transmission to give optimum efficiency in the cruise range and optimum acceleration in the performance range.

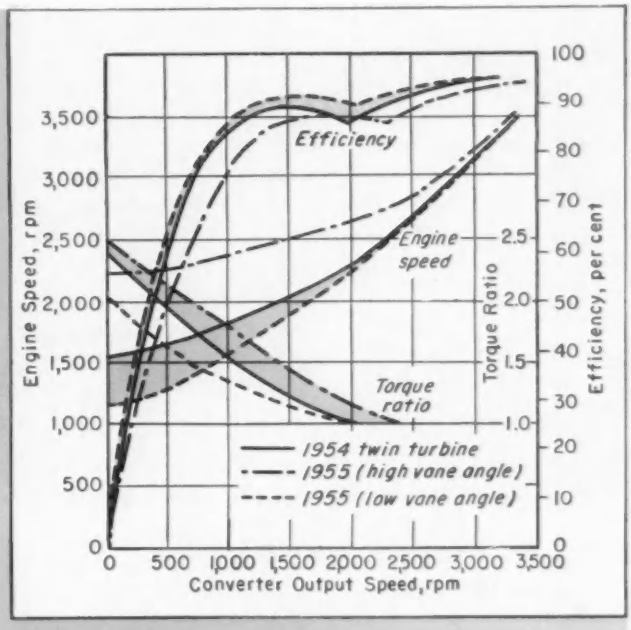
The new stator assembly can be likened to a small circular venetian blind in which twenty slats or vanes are moved hydro-mechanically like the blades of an airplane propeller. To achieve complete reliability of this transmission sub-assembly, the principal parts, notably the vanes and outer ring, are fabricated according to an ingenious sequence of manufacturing techniques.

The transition from cruise operation to passing or performance operation is smooth because it is accomplished by changing the converter fluid flow instead of by shifting clutches or bands. The effect on performance from low to high vane angle is greatest at low car speeds and gradually diminishes as the coupling range is approached, which is at approximately 60 mph under full throttle operation. This provides the safety feature of a "passing performance," which some automatic transmissions have as a "passing gear."

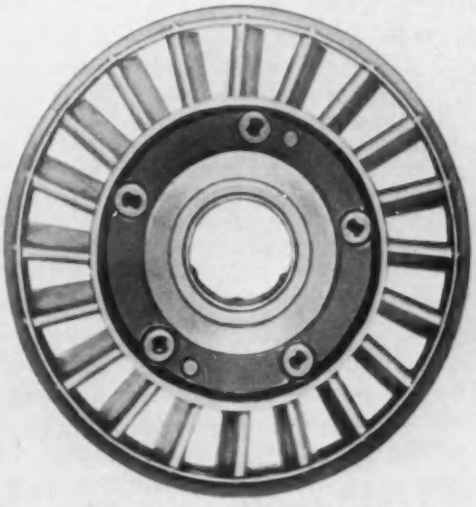
At higher car speeds or in the converter coupling range, engine power alone provides the performance.

(LEFT) Each of the twenty blades of the stator assembly is mounted on an individual crank pin, which is actuated by the stator piston. Oil pressure on one or both sides of the piston moves the blades to either the low or high angle positions, these being the cruise and performance positions, respectively. The position of the stator blade angle depends on throttle position. Throttle linkage from the engine actuates a valve in the high accumulator body. For all throttle openings, up to and including full throttle, high clutch oil pressure of 100 psi is routed through the control valve to the front side of the stator piston. Since this pressure is greater than converter charging pressure of 40 psi, the piston will move to the rear of the stator unit and the blades will be positioned in low angle. This will give the converter a low stall speed.

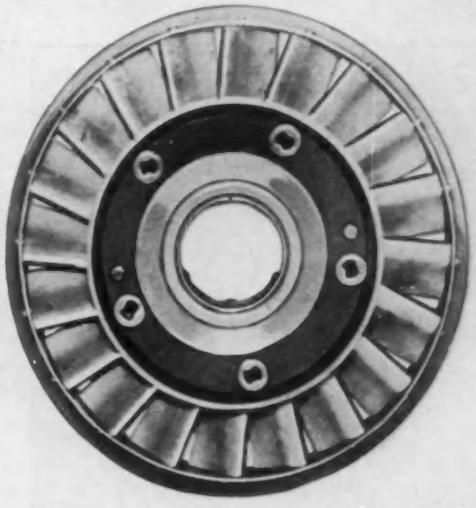
High stator blade angle is obtained after full throttle position is reached. Throttle linkage moves the control valve in the high accumulator body, thus closing off high clutch pressure and exhausting the oil from the front side of the stator piston. Converter charging pressure on the rear side of the piston then moves the piston to the high angle position. In so doing, the blades are shifted approximately 75 deg from the low angle position and the stall speed and torque multiplication of the converter are increased. This is the performance range.



THE 1954-1955 comparison curves show the differences in engine speed, torque ratio and efficiency for an input torque of 170 ft-lb. The solid lines are the 1954 reference curves; the dash lines are the 1955 low stator vane angle curves; and the dot-dash lines are the 1955 high stator vane angle curves.



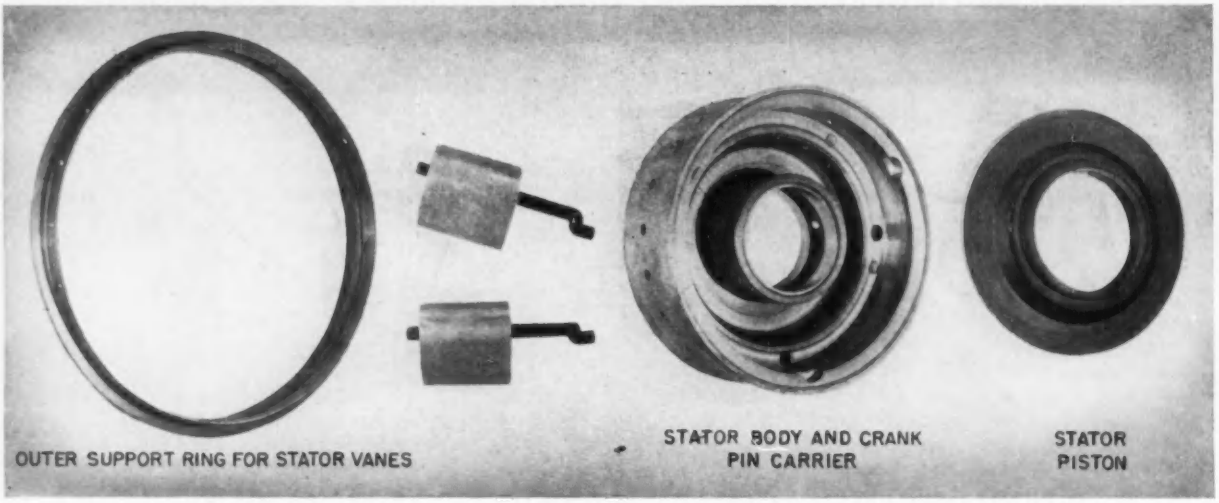
LOW VANE ANGLE FOR CRUISE



HIGH VANE ANGLE FOR PERFORMANCE

HERETOFORE, with fixed stator vanes, engineers have had to compromise between performance and economy by establishing a stator vane angle and contour. With the new Dynaflow, they have made it possible for the driver to change the angle of the vanes by pressing the accelerator so that the best angle for economy is used for cruising or the best angle for performance is used for accelerating. For normal acceleration and cruising in drive range, the stator vanes are in low angle or nearly parallel to the axis of the stator assembly as shown at left. This provides the largest openings between the vanes for freedom of oil movement through the stator and a minimum amount of redirecting of the converter oil flow. Less engine rpm and more efficient operation also result. Under performance conditions, the stator vanes are in high angle or like a venetian blind partially closed as in right-hand view. This provides the greatest redirecting of the converter oil flow and the resultant higher converter torque ratio. It also permits the engine speed to increase so that it can develop more power.

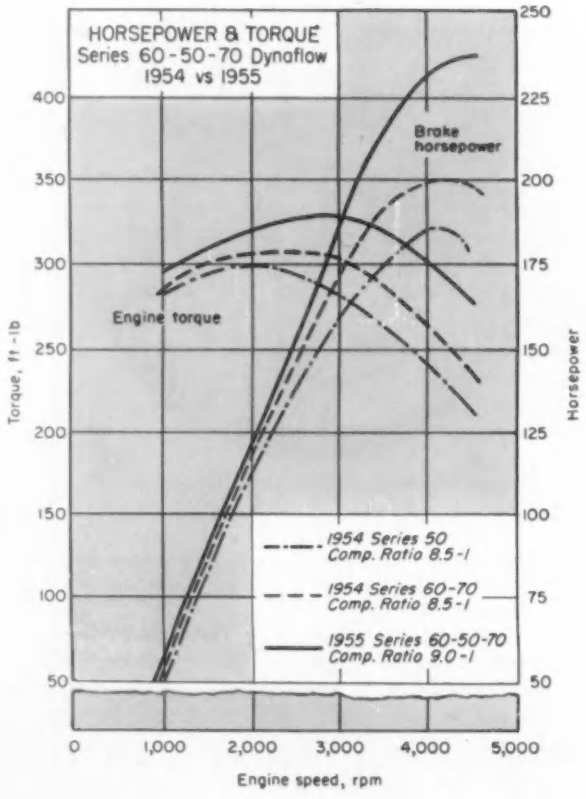
(*Continued on next page*)



THE REDESIGN of the stator assembly parts for mass production resulted in several interesting features. These centered principally around the steel outer ring and aluminum vanes. In making the ring, a piece of SAE 1008 sheet is drawn into a cup. The dome and flange are trimmed off, leaving a cylinder or section of seamless tubing. The ends are then pressed toward each other axially between dies which keep the ends in alignment while the center section forms the rib. The inside diameter is maintained constant by an internal arbor. Final operation is punching of the twenty crank pin holes in one flange.

In fabricating the vane assembly, 63S aluminum is extruded to a shape several thousandths larger than desired. The long extrusion is cold drawn through a die to obtain exact contour dimensions and then cut to proper length. Finally, a hole is broached in the vane and the serrated crank pressed into place. To reduce assembly time, one end of the vane is twisted to final contour while vane is still clamped in the pressing jig.

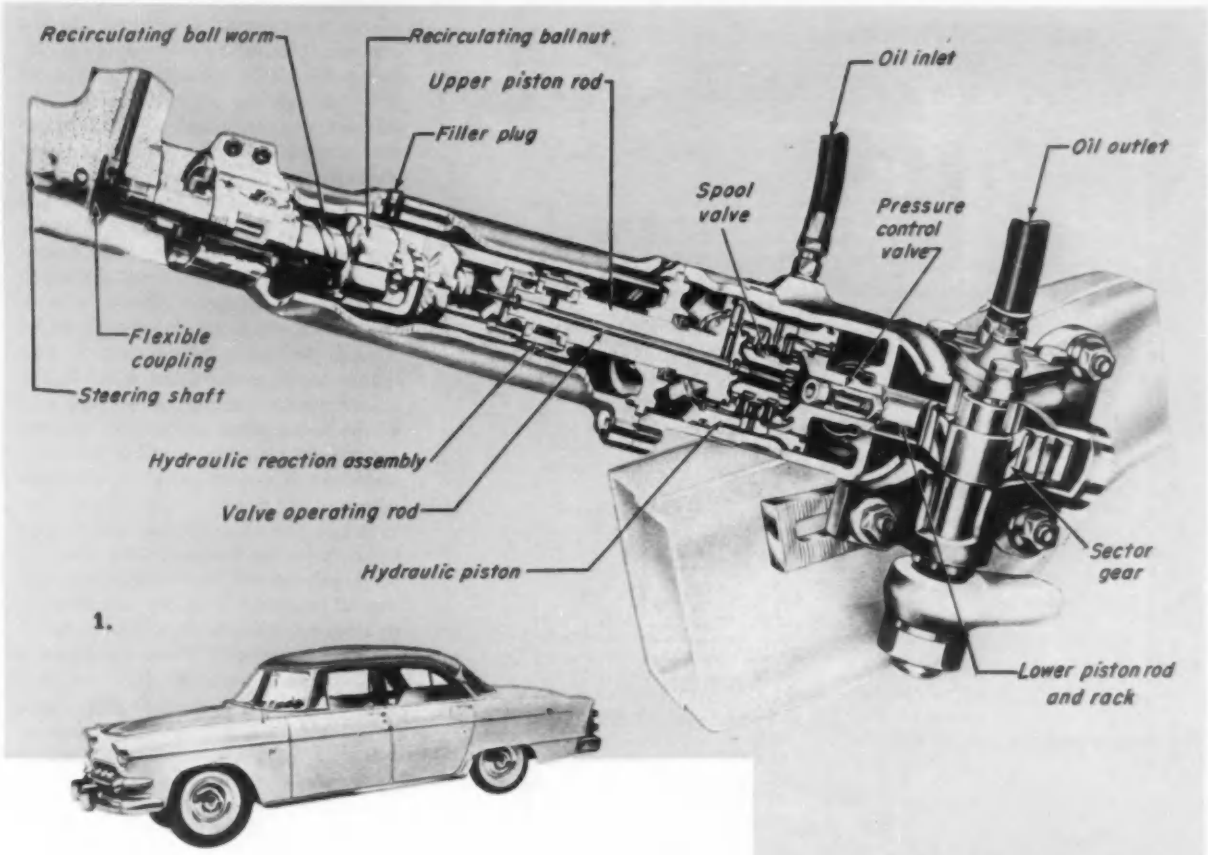
To permit presassembly of the vane and its crank pin, the stator vane carrier is made in two pieces with the parting line through the centers of the crank pin holes. Thus in assembling the whole vane unit, the ends of the cranks are easily positioned in the outer ring flange and the piston groove, to facilitate the front and rear sections of the carrier being mated around the crank pins.



CHARACTERISTICS of three basically different converters are given in the table. The 1955 transmission has two completely different sets of characteristics. In the low angle position, engine speed, compared with former years, is reduced for a given car speed throughout the conversion range. In the high angle position, the 1955 transmission improves upon 1954 units through two transmission modifications, as well as through increased engine power. First, converter torque ratio is increased from 2.45:1 to 2.50:1; and second, transmission allows the engine to speed up to the point where it develops near maximum torque, thus utilizing the engine in its most favorable condition for performance.

Torque Ratios and Stall Speeds of Dynaflow Transmissions: 1952-1955

Type Transmission	Stall Speed, rpm	Torque Ratio	
		Drive Range	Low Range
1952 Five Element			
Series 40–50	1,800	2.25	4.10
Series 70	1,600	2.25	4.10
1953–54 Twin Turbine			
All Series	1,700	2.45	4.46
1955 Variable Pitch			
All Series			
Low Angle (Cruise)	1,400	2.10	....
High Angle (Perform)	2,600	2.50	4.55

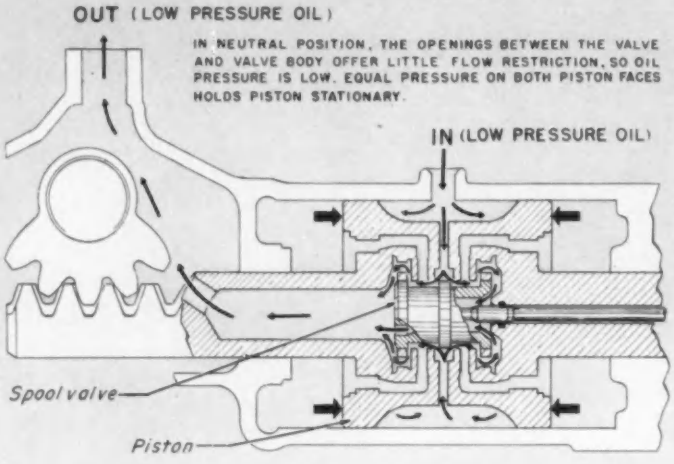


Coaxial Design Features Chrysler Power Steering

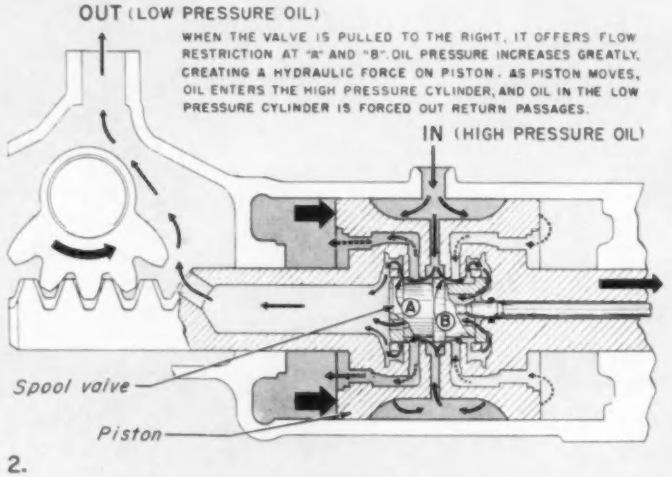
Through ingenious design, Chrysler engineers have fitted all the components of their 1955 power steering system into a slim, tubular housing for location coaxially with the steering column axis. This design results in a neat, slender unit that is easily installed in the engine compartment without interfering with the starter, brake pedal, clutch pedal or other nearby parts. The gear fastens to the steering column at the underside of the instrument panel and extends down through the toe boards to a bracket bolted to the frame. In this headline automotive engineering feature, careful construction is just as essential as imaginative design if the steering unit is to operate quickly and surely without sluggishness; no extraneous free play can be tolerated in the system. Thus, construction details and the control of manufacturing variations received special attention, resulting in a practical steering gear that ensures quick, positive response and a real "feel" of the road. The gear offers efficient space utilization, has fewer parts and weighs less than any other integral-type power steering unit on the market.

1. The coaxial power steering unit incorporates two separate gear mechanisms: a worm and recirculating ball nut, and a rack and sector gear. The worm and ball nut act like a bolt and nut assembly, and rotation of the worm causes linear (axial) motion of the ball nut. Fastened to the ball nut are the upper piston rod, piston and lower piston rod, all coaxial to the steering column axis. Machined in the bottom portion of the lower piston rod is a rack that meshes with the sector gear. Working together, the latter produce rotation of the steering gear arm and thereby actuate the steering linkage connected to the wheels.

The hydraulic system consists of a double-acting piston, a spool valve which fits inside the piston and a hydraulic reaction chamber which gives the driver the "feel" of the road. Axial positioning of the spool valve directs high pressure oil to one side or the other of the double-acting piston. At the same time, valve movement opens a return line which leads oil from the low pressure side of the piston to the


OUT (LOW PRESSURE OIL)
IN NEUTRAL POSITION, THE OPENINGS BETWEEN THE VALVE AND VALVE BODY OFFER LITTLE FLOW RESTRICTION, SO OIL PRESSURE IS LOW. EQUAL PRESSURE ON BOTH PISTON FACES HOLDS PISTON STATIONARY.
IN (LOW PRESSURE OIL)
Spool valve
Piston

OIL FLOW-NEUTRAL VALVE POSITION


OUT (LOW PRESSURE OIL)
WHEN THE VALVE IS PULLED TO THE RIGHT, IT OFFERS FLOW RESTRICTION AT "A" AND "B". OIL PRESSURE INCREASES GREATLY, CREATING A HYDRAULIC FORCE ON PISTON. AS PISTON MOVES, OIL ENTERS THE HIGH PRESSURE CYLINDER, AND OIL IN THE LOW PRESSURE CYLINDER IS FORCED OUT RETURN PASSAGES.
IN (HIGH PRESSURE OIL)
A
B
Spool valve
Piston

2.

OIL FLOW—VALVE PULLED TO RIGHT

oil reservoir. The direction of oil flow always turns the road wheels in the direction of the steering wheel rotation.

Other components of the hydraulic system are a generator-driven oil pump, with pressure relief valve and flow control valve, and a filter with the oil reservoir. The flow control valve limits the oil flow to a predetermined maximum of two gallons per minute and thus holds to a minimum the horsepower required to drive the oil pump. The oil pressure in the power steering system is limited to 800 psi to prevent excessive stress developing in the steering linkage.

To prevent excessive oil pressure in the return line when the oil is cold, a spring-loaded relief valve opens and permits oil to enter the reservoir chamber directly.

2. The heart of the coaxial power steering unit has two parts: the spool valve and the spool valve body which is actually a part of the hydraulic piston. When the driver turns the steering wheel, he moves the spool valve with respect to the hydraulic piston, and power assistance responds to his commands. The relative movement between the valve and piston is very slight (seldom exceeding 0.0025 in.) and should not be confused with the general movement of the whole steering system as the road wheels turn. As the spool valve moves relative to the piston, it regulates oil pressure and directs oil through the hydraulic circuit.

Consider the case where the steering wheel is not turned (top view). In this position, the valve leaves openings between it and the valve body so that oil flows through the unit easily. Thus the oil pump has only a slight resistance to overcome, and the oil entering the power steering unit is under low pressure. Inside the unit, the oil reaches the spool valve through holes in the piston. At the valve, the flow divides and travels toward both ends of the valve, twisting through succeeding openings as shown until it reaches the main return passage drilled through the lower piston rod. It then returns to the reservoir and filter. In this neutral position, oil pressure on both sides of the power piston is the same. Consequently, the piston remains stationary and there is no movement of the front wheels.

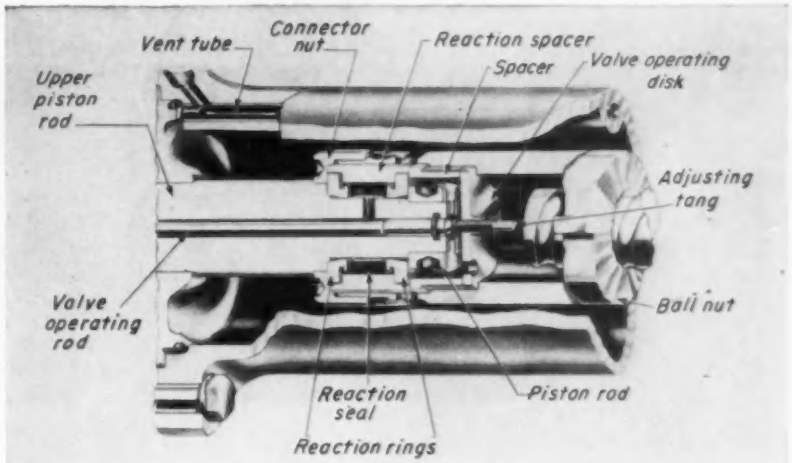
When the driver turns the steering wheel, he moves the spool valve either upward or downward, depending on which direction he turns. Take the case when he pulls the valve to the right, relative to the piston (bottom view). The instant the valve is moved with respect to the piston, two things happen: (1) the inlet oil pressure increases because of restricted openings between the valve and valve body; and (2) the increased pressure is directed to one side of the power piston. The restrictions causing the pressure rise are marked A and B. These narrow spaces "dam up" the oil that is being forced through the system by the positive-displacement pump. As the oil "piles-up" behind the restrictions, pressure increases, squeezing oil through the narrow spaces rapidly. The maximum pressure build-up is limited to 800 psi by a pressure relief valve in the pump assembly. The high oil pressure is directed to the lower piston face (in this example) through the passages indicated. However, the opposite piston face being open to the return line, there is a difference in pressure between the two faces. This moves the piston and the road wheels turn.

The piston is heat-treated malleable cast iron which has high strength without brittleness—a property not possessed of ordinary gray cast iron. Malleable iron also has excellent machining properties.

All ring faces are required to be parallel within very close tolerances to ensure uniform shut-off all around the spool valve. After the faces have been individually ground, the five rings are clamped together on an arbor and finished-ground on the outside diameter. While still on the arbor, the rings are pressed into the piston and positioned inside by a locating shoulder on the arbor. In the final step, the spool valve body as an assembly is finished-ground and honed on the inside diameter.

3. The piston and spool valve control the operation of the hydraulic system. The spool valve body consists of five steel disks frozen inside the piston. The rings are fine-grained high quality steel, case-hardened on the ID to preserve the sharp ground edges needed for proper valve action. The spool valve is forged from fine-grained steel, ground and lapped on the OD, and case-hardened to safeguard the sharp edges. The steel valve-operating rod that connects the spool valve to the hydraulic reaction assembly is purposely made flexible. In this way, any slight misalignment in the valve and piston assembly is compensated by flexing of the rod. Both the upper and lower piston rods are steel forgings carefully ground on the OD. Each rod passes through an aluminum bulkhead which acts as a retaining wall for the high pressure oil. In addition, the upper bulkhead serves as a bearing and support for the entire power train. Very few seals are needed throughout the coaxial power unit. Although O-ring, L-ring and spring loaded lip-type seals are used, all are made from oil-resistant synthetic rubber. Piston rings are rubber L-ring seals backed with thin steel supporting rings. The spring-loaded piston rod seals used at each bulkhead are backed with steel to keep shape and rigidity.

The tapered snap rings that fasten the piston and piston rods together aid in providing positive hydraulic action by eliminating free play between rods and piston. Spring tension locks wedge-shaped ring tightly into adjoining groove in piston, forcing piston rod against piston.



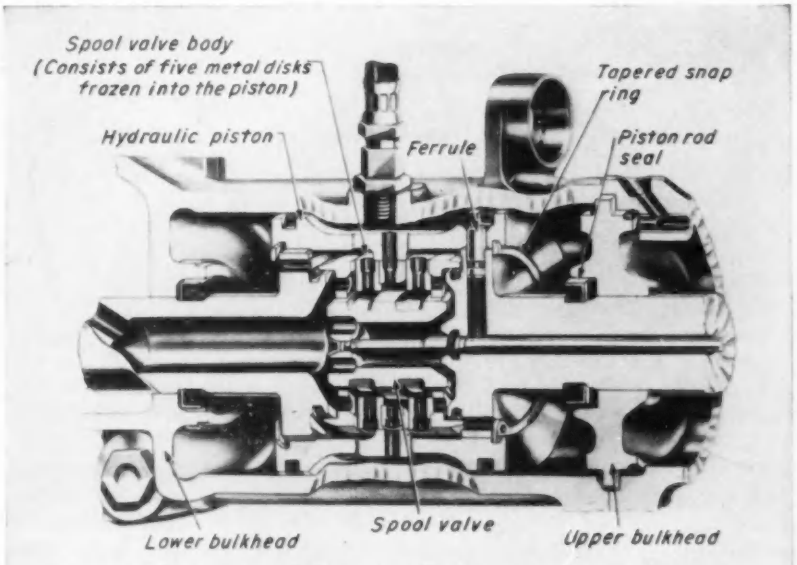
HYDRAULIC REACTION ASSEMBLY

4.

4. Hydraulic reaction unit gives the driver the "feel" of the road by resisting the relative movement between the spool valve and piston. The connector nut, two spacers and valve operating disk are in effect parts of the ball nut assembly. Likewise, the piston rod nut and lock collar are functionally parts of the upper piston rod. The connector nut screws into the ball nut and clamps the spacers and operating disk against a shoulder inside the ball nut. To conserve space, the connector nut is made round rather than hexagonal. The piston rod nut holds the two reaction rings and the seal in place. Tangs on the lock collar fit into grooves in the upper piston rod to prevent angular motion. The upper and lower sections of the main housing are joined at the upper bulkhead by three bolts.

In the top left corner, a portion of the upper housing vent tube is visible. This tube opens the upper housing to the atmosphere and prevents high pressure build-up in the upper housing during movement of upper piston rod into worm housing.

All metal parts of the hydraulic reaction unit are ground steel. The reaction spacer is the only part that must be selectively fitted to insure proper operation. It must exactly fit in the space between the piston rod nut and the piston rod shoulder (the space that contains the two reaction rings and seal). Otherwise, there will be an undesired clearance in the system. The proper size reactor spacer is chosen by a color code system. The reaction seal is molded from neoprene, an oil resistant synthetic rubber. The face area of the seal is precisely controlled, for the size directly influences the steering effort required. A larger area would cause a greater resistance to the turning because oil pressure would act on a larger surface area. In the assembling of the power steering unit, the setting must be made to the neutral valve position (the spool valve centered in the valve body). This is accomplished by screwing the valve operating rod in or out of the valve operating disc; the threaded end of the valve operating rod has a rectangular tang. A long slotted tool is fitted down through the ball nut and over the tang. The valve may be moved up or down by turning the tang. The valve is then adjusted while oil from a test stand flows through the hydraulic system.



HYDRAULIC PISTON AND SPOOL VALVE ASSEMBLY

3.

PLATE CAM DESIGN . . .

. . . *With Emphasis on Dynamic Effects*

Complete design data—including tables, charts and graphs—to facilitate the selection and blending of profile curves. How to apply the method of profile synthesis to minimize inertia forces for high speed operation.

M. KLOOMOK and R. V. MUFFLEY
International Business Machine Corporation

THE WORK, friction, spring and gravity forces of a cam system are essentially independent of the motion provided by the cam. However, inertia forces depend directly on the cam profile; therefore, as operating speeds increase, it becomes mandatory to select profiles on the basis of these inertia forces and other dynamic characteristics.

Consider the typical application shown in Fig. 1. The cam must provide a rise from *B* to *C* in 90 deg, but the intermediate points are not specified. The simplest motion would be a straight line between points *B* and *C*.

A cursory consideration of the acceleration diagram in Fig. 2 is sufficient to disqualify straight-line motion. To start with a finite velocity, the follower system must be instantaneously accelerated. The average acceleration is:

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v - 0}{0} = \infty$$

Because of its elasticity, the actual system would cushion the theoretically infinite acceleration force; nevertheless, the forces developed would be extremely high, and the cam surface would soon spall or mushroom at the start of the rise unless the speed were very slow.

By connecting points *B* and *C* with a pair of parabolas rather than a straight line, the velocity at the beginning and end remain zero and therefore infinite accelerations are avoided. The relationship between displacement and time over the parabola *BC'* (Fig. 3) is given by.

$$\left.\begin{aligned} y &= 2h\left[\frac{\theta}{\beta}\right]^2 \\ v &= \frac{4h}{\beta}\left[\frac{\theta}{\beta}\right] \\ a &= \frac{4h}{\beta^2} \end{aligned}\right\} 0 \le \theta \le \frac{\beta}{2}$$

Since these expressions are equivalent to the equations for a body in free fall under the action of gravity, the parabolic motion is often referred to as a "gravity" or "constant acceleration" motion.

As seen in Fig. 3, acceleration is constant over the half curve *BC'*. It can be shown that this value of acceleration is the lowest possible value for any curve joining points *B* and *C*, and for this reason, parabolic profiles have been used in many applications. Service has been satisfactory at low speeds; however, higher speeds often produced a rapid deterioration of the cam surface and similar deleterious effects on the driven mechanism.

These effects have led to a reconsideration of the dynamic properties of cam profiles and to the realization that the

BASIC RELATIONSHIPS

The usual starting point in cam design is a plot of the displacement desired versus time (timing diagram) and at least a rough sketch of the mechanism to be driven by the cam. These data may be resolved into a mass m and an acceleration a. According to Newton's Law, the corresponding interia force F equals ma. By D'Alembert's Principle, this force, together with work resistance and friction, spring and gravity forces, may be used to calculate stresses and deflections in the mechanism.

In most timing diagrams, the specified displacements and velocities are expressed in terms of degrees of cam rotation.

Displacement (translational or rotary)

$$y = f(\theta) \text{ in. (or deg)}$$

where y is the position of the point of interest (follower, output, etc., as the case may be) and θ is the cam rotation.

Velocity

$$v = \frac{dy}{d\theta} = \frac{d}{d\theta}[f(\theta)] \text{ in./deg or deg/deg}$$

Acceleration

$$a = \frac{d^2y}{d\theta^2} = \frac{d^2}{d\theta^2}[f(\theta)] \text{ in./(deg)}^2 \text{ or deg/(deg)}^2$$

To calculate forces by Newton's Equation, acceleration must be expressed as a function of time. Usually this transformation is easily made, because the large majority of cams are rotated at constant velocity ω.

$$y = f(\theta) = f(\omega t)$$

$$v_t = \frac{dy}{dt} = \frac{dy}{d\theta}\frac{d\theta}{dt} = \omega\frac{dy}{d\theta} = \omega\frac{d}{d\theta}[f(\theta)]$$

$$a_t = \frac{d^2y}{dt^2} = \frac{d}{dt}\left[\omega\frac{dy}{d\theta}\right] = \omega^2\frac{d^2y}{d\theta^2} = \omega^2\frac{d^2}{d\theta^2}[f(\theta)]$$

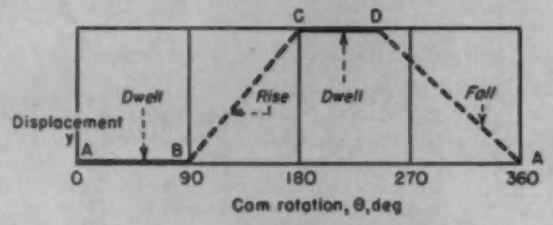


Fig. 1—Typical timing diagram used as starting point in cam design.

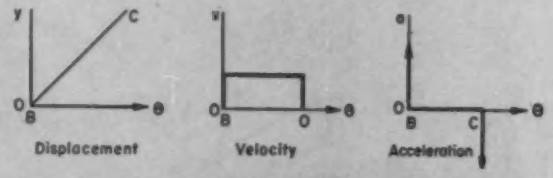


Fig. 2—Characteristics of straight line motion shows theoretically infinite accelerations occur at beginning and end of cam rise.

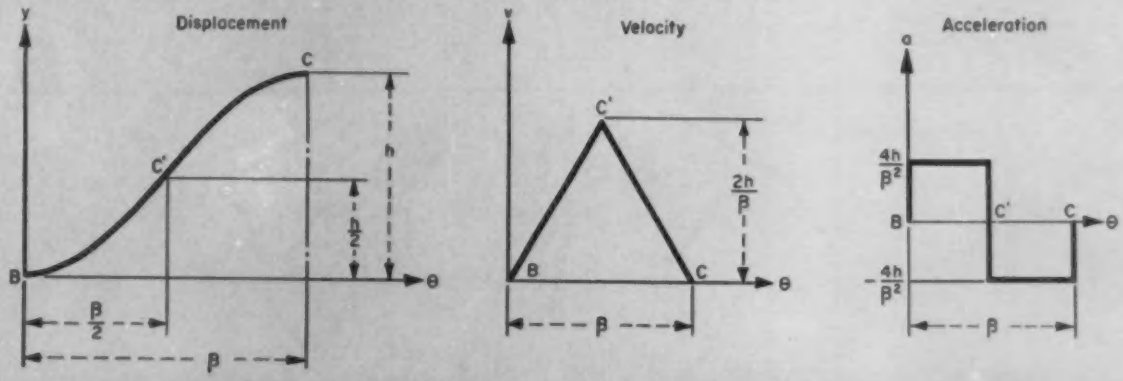


Fig. 3—Parabolic profile theoretically has lowest value of acceleration possible for any curve joining B and C. However, high speed characteristics of these cams are not satisfactory for most applications.

rate of change of acceleration, or "jerk," is as pertinent as the value of acceleration itself.

Referring again to the acceleration diagram of the parabolic curve, it is seen that a finite acceleration (or deceleration) is applied in zero time at B, the beginning of the rise, C', the midpoint of the rise, and C, the end of the rise.

Jerk at these points is infinite:

$$j = \frac{\Delta a}{\Delta t} = \frac{\Delta a}{0} = \infty$$

The infinite jerk at point B is equivalent to an instantaneous application of the acceleration force. The effect of such an instantaneous application of a force on a system with mass and resilience is demonstrated by the example illustrated in Fig. 4.

Case I. The load has been gradually increased from zero to W, with a resulting static deflection y_{st} and static stress s_{st}.

Case II. The load has been suddenly applied (instan-

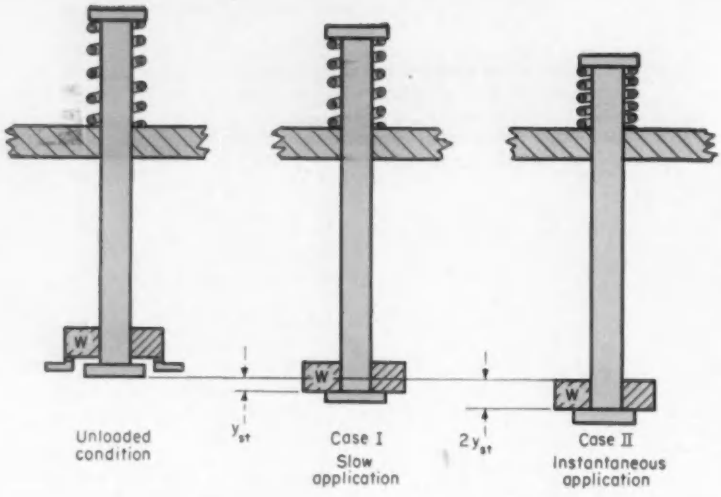


Fig. 4—Effect of sudden change of acceleration illustrated by weight dropping on spring-loaded rod. The spring is momentarily deflected to twice the static deflection. ("Elements of Strength of Materials," Timoshenko and MacCullough).

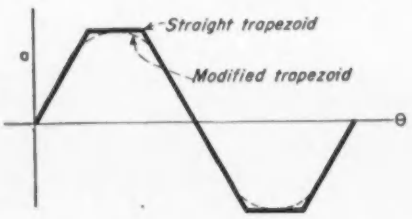


Fig. 5—Trapezoidal acceleration diagram.

Motion Characteristics of Three Cam Profile Curves

I CYCLOIDAL MOTION CHARACTERISTICS (Fig. 6)

C1

$y = h\left(\frac{\theta}{\beta} - \frac{1}{\pi}\sin\pi\frac{\theta}{\beta}\right)$

$v = \frac{h}{\beta}\left(1 - \cos\pi\frac{\theta}{\beta}\right)$

$a = \frac{\pi h}{\beta^2}\left(\sin\pi\frac{\theta}{\beta}\right)$

θ/β	0	1/2	1
y	0		h *
v	0		2h/β *
a	0	π h/β²*	0

C2

$y = h\left(\frac{\theta}{\beta} + \frac{1}{\pi}\sin\pi\frac{\theta}{\beta}\right)$

$v = \frac{h}{\beta}\left(1 + \cos\pi\frac{\theta}{\beta}\right)$

$a = -\frac{\pi h}{\beta^2}\left(\sin\pi\frac{\theta}{\beta}\right)$

θ/β	0	1/2	1
y	0		h *
v	2h/β *		0
a	0	-π h/β²*	0

C3

$y = h\left(1 - \frac{\theta}{\beta}\frac{1}{\pi} + \sin\pi\frac{\theta}{\beta}\right)$

$v = -\frac{h}{\beta}\left(1 - \cos\pi\frac{\theta}{\beta}\right)$

$a = -\frac{\pi h}{\beta^2}\left(\sin\pi\frac{\theta}{\beta}\right)$

θ/β	0	1/2	1
y	h *		0
v	0		-2h/β *
a	0	-π h/β²*	0

C4

$y = h\left(1 - \frac{\theta}{\beta} - \frac{1}{\pi}\sin\pi\frac{\theta}{\beta}\right)$

$v = -\frac{h}{\beta}\left(1 + \cos\pi\frac{\theta}{\beta}\right)$

$a = \frac{\pi h}{\beta^2}\left(\sin\pi\frac{\theta}{\beta}\right)$

θ/β	0	1/2	1
y	h *		0
v	-2h/β *		0
a	0	π h/β²*	0

C5

$y = h\left(\frac{\theta}{\beta} - \frac{1}{2\pi}\sin 2\pi\frac{\theta}{\beta}\right)$

$v = \frac{h}{\beta}\left(1 - \cos 2\pi\frac{\theta}{\beta}\right)$

$a = \frac{2\pi h}{\beta^2}\left(\sin 2\pi\frac{\theta}{\beta}\right)$

θ/β	0	1/4	1/2	1/4	1
y	0		1/2		1 *
v	0		2h/β *		0
a	0	2π h/β²*	0	-2π h/β²*	0

C6

$y = h\left(1 - \frac{\theta}{\beta} + \frac{1}{2\pi}\sin 2\pi\frac{\theta}{\beta}\right)$

$v = -\frac{h}{\beta}\left(1 - \cos 2\pi\frac{\theta}{\beta}\right)$

$a = -\frac{2\pi h}{\beta^2}\left(\sin 2\pi\frac{\theta}{\beta}\right)$

*max

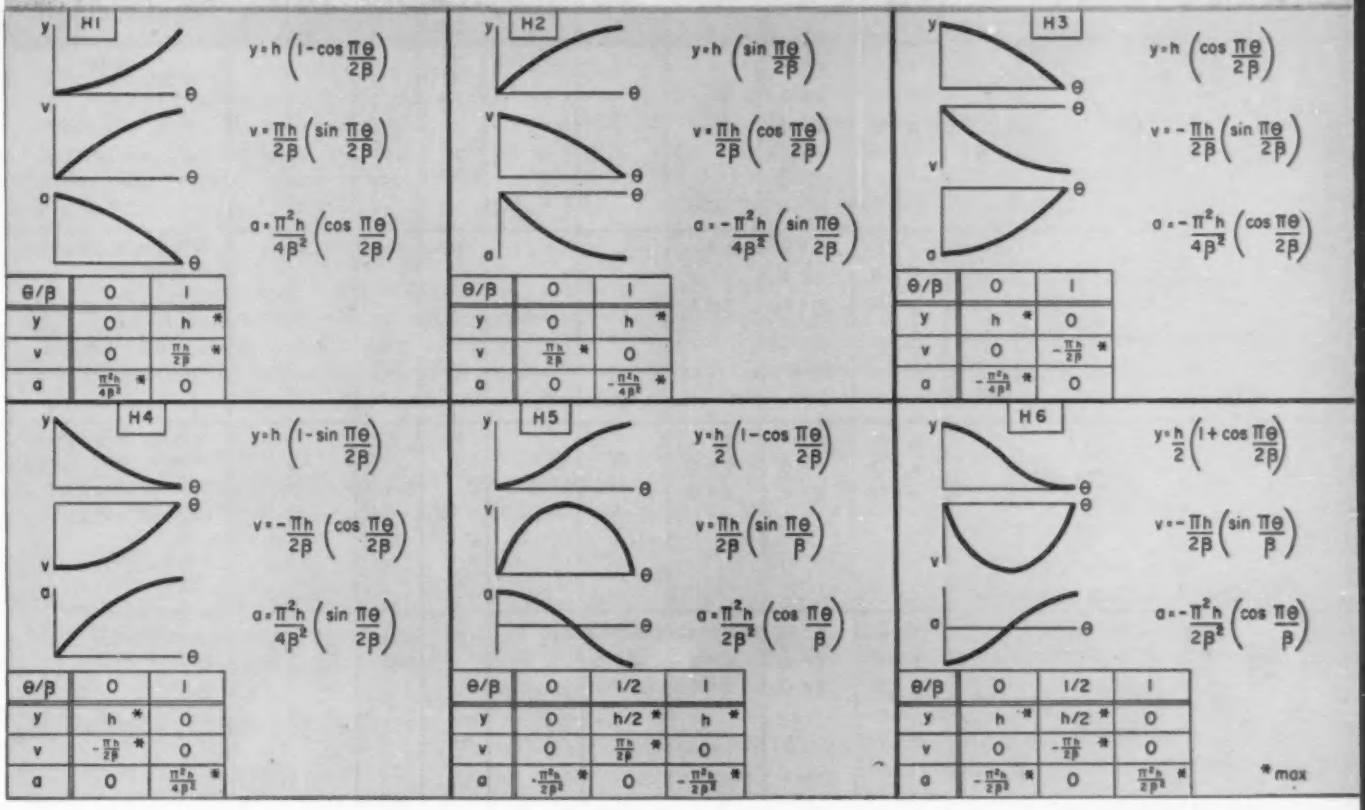
θ/β	0	1/4	1/2	3/4	1
y	h *		1/2		0
v	0		-2h/β *		0
a	0	-2π h/β²*	0	2π h/β²*	0

taneous acceleration or infinite jerk). The kinetic energy of the load carries the spring down until the rising potential energy of the spring balances the energy of the load at $2y_{st}$. The corresponding stress is $2s_{st}$. The weight then bounces back, oscillating about y_{st} until damped out.

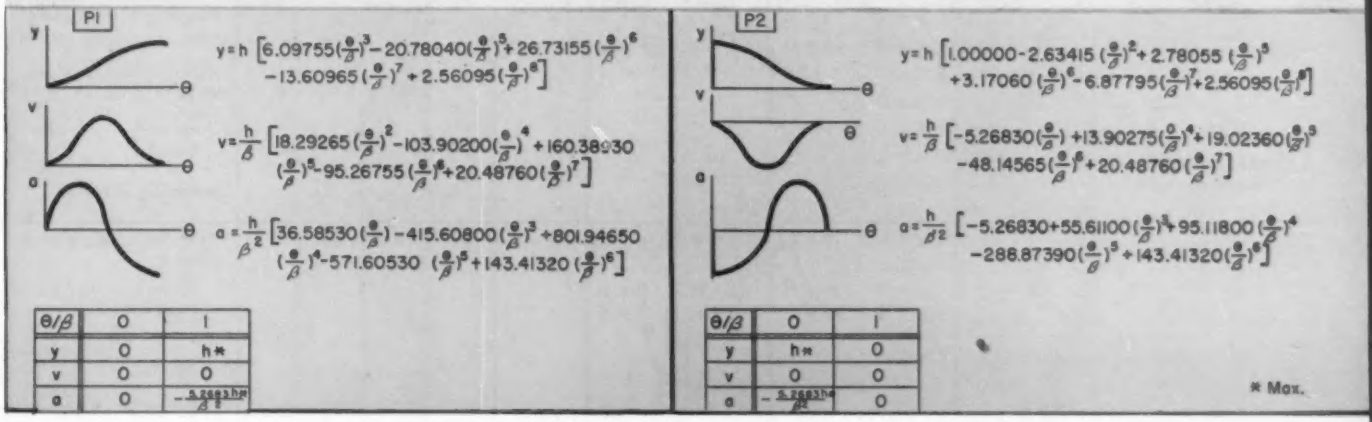
At point C′ the midpoint of the rise in the parabolic profile, acceleration changes instantaneously from full plus to full minus. As shown by Hrones (Ref 1) and Mitchell (Ref 2), with no damping the corresponding peak force is triple the computed value based on acceleration, and it is not surprising that the crossover point of the cam should be subject to rapid disintegration in high-speed parabolic cam systems.

One solution to this problem is to ease the points of acceleration change, giving a trapezoidal acceleration curve, Fig. 5. Neklutin (Ref 3) has found that barrel cams of this shape cause less jerk and vibration than any of the other profiles which he studied. However, the profile

2. HARMONIC MOTION CHARACTERISTICS (Fig. 7)



3. EIGHTH POWER POLYNOMIAL MOTION CHARACTERISTICS (Fig. 8)


P1
$y = h\left[6.09755\left(\frac{\theta}{\beta}\right)^3 - 20.78040\left(\frac{\theta}{\beta}\right)^5 + 26.73155\left(\frac{\theta}{\beta}\right)^6 - 13.60965\left(\frac{\theta}{\beta}\right)^7 + 2.56095\left(\frac{\theta}{\beta}\right)^8\right]$
$v = \frac{h}{\beta}\left[18.29265\left(\frac{\theta}{\beta}\right)^2 - 103.90200\left(\frac{\theta}{\beta}\right)^4 + 160.38930\left(\frac{\theta}{\beta}\right)^5 - 95.26755\left(\frac{\theta}{\beta}\right)^6 + 20.48760\left(\frac{\theta}{\beta}\right)^7\right]$
$a = \frac{h}{\beta^2}\left[36.58530\left(\frac{\theta}{\beta}\right) - 415.60800\left(\frac{\theta}{\beta}\right)^3 + 801.94650\left(\frac{\theta}{\beta}\right)^4 - 571.60530\left(\frac{\theta}{\beta}\right)^5 + 143.41320\left(\frac{\theta}{\beta}\right)^6\right]$
P2
$y = h\left[1.00000 - 2.63415\left(\frac{\theta}{\beta}\right)^2 + 2.78055\left(\frac{\theta}{\beta}\right)^3 + 3.17060\left(\frac{\theta}{\beta}\right)^6 - 6.87795\left(\frac{\theta}{\beta}\right)^7 + 2.56095\left(\frac{\theta}{\beta}\right)^8\right]$
$v = \frac{h}{\beta}\left[-5.26830\left(\frac{\theta}{\beta}\right) + 13.90275\left(\frac{\theta}{\beta}\right)^4 + 19.02360\left(\frac{\theta}{\beta}\right)^5 - 48.14565\left(\frac{\theta}{\beta}\right)^6 + 20.48760\left(\frac{\theta}{\beta}\right)^7\right]$
$a = \frac{h}{\beta^2}\left[-5.26830 + 55.61100\left(\frac{\theta}{\beta}\right)^3 + 95.11800\left(\frac{\theta}{\beta}\right)^4 - 288.87390\left(\frac{\theta}{\beta}\right)^5 + 143.41320\left(\frac{\theta}{\beta}\right)^6\right]$
* Max.

cannot be represented by a continuous function, and cam calculations tend to become exceedingly complex.

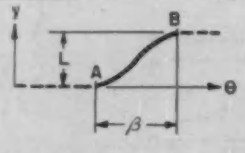
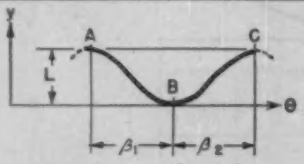
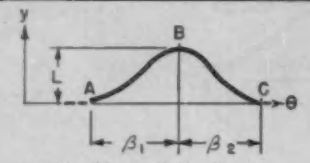
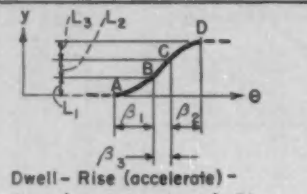
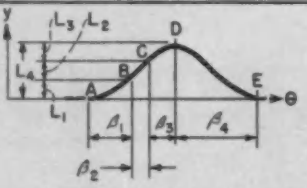
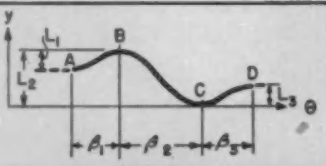
Three analytic functions that have been found extremely useful are: (1) Cycloid (and Half-Cycloid), (2) Harmonic (and Half-Harmonic), and (3) Eighth Power Polynomial.[1] The dynamic properties of these curves are illustrated in Figs. 6, 7 and 8.

[1] *This polynomial was derived by Mr. E. A. Barber, Laboratory Assistant Manager for Research at the IBM Endicott Laboratories.*

METHOD OF PROFILE SYNTHESIS

Used singly or in combination, these three curves offer effective solutions to the majority of functional situations encountered in cam design. The curves have continuous derivatives at all intermediate points; thus acceleration changes gradually and jerk is finite. Infinite jerk is avoided at the end points by matching accelerations. For example, when a rise follows a dwell, the zero acceleration at the

Table I—Cam Curve Synthesis Used to Satisfy Various Functional Requirements

CAM TYPE	REQUIREMENTS AT PRINCIPAL POINTS					CURVES SELECTED *				NECESSARY CONDITIONS TO MATCH VELOCITIES AND/OR ACCELERATIONS
	A	B	C	D	E	A-B	B-C	C-D	D-E	
 Dwell - Rise - Dwell	$y = 0$ $v = 0$ $a = 0$	$y = L$ $v = 0$ $a = 0$				C5				None
 Fall - Rise ... (cycle)	$y = L$ $v = 0$ $a = a_1$	$y = 0$ $v = 0$ $a = a_1$	$y = L$ $v = 0$ $a = a_1$			H6	H5			To match accelerations at point B, $\beta_1 = \beta_2$
 Dwell - Rise - Fall - Dwell	$y = 0$ $v = 0$ $a = 0$	$y = L$ $v = 0$ $a = a_1$	$y = 0$ $v = 0$ $a = 0$			P1	P2			To match accelerations at point B, $\beta_1 = \beta_2$
 Dwell - Rise (accelerate) - Rise (constant velocity) - Rise (decelerate) - Dwell	$y = 0$ $v = 0$ $a = 0$	$y = L_1$ $v = v_1$ $a = 0$	$y = L_1 + L_2$ $v = v_1$ $a = 0$	$y = L_1 + L_2 + L_3$ $v = 0$ $a = 0$		C1	Const. vel.	C2		To match velocities at points B and C, $2L_1/\beta_1 = v_1 = \pi L_3/2\beta_3$ also $v_1 = L_2/\beta_2$;
 Dwell - Rise (accelerate) Rise (constant velocity) Rise (decelerate) - Fall - Dwell	$y = 0$ $v = 0$ $a = 0$	$y = L_1$ $v = v_1$ $a = 0$	$y = L_1 + L_2$ $v = v_1$ $a = 0$	$y = L_1 + L_2 + L_3$ $v = 0$ $a = a_1$	$y = 0$ $v = 0$ $a = 0$	C1	Const. vel.	H2	P2	To match velocities at points B and C, $2L_1/\beta_1 = v_1 = 2L_3/\beta_3$ also, $v_1 = L_2/\beta_2$ To match accelerations at point D, $\frac{\pi^2}{4}\frac{L_3}{\beta_3^2} = \frac{2C_0 L_4}{\beta_4^2}$ where $C_0 = 2.63415$
 Dwell - Rise - Fall - Rise - Dwell	$y = L_2 - L_1$ $v = 0$ $a = 0$	$y = L_2$ $v = 0$ $a = -a_1$	$y = 0$ $v = 0$ $a = a_1$	$y = L_3$ $v = 0$ $a = 0$		P1	H6	P1		To match acceleration at point B, $\frac{2C_0 L_1}{(\beta_1)^2} = \frac{L_2}{2(\beta_2)^2}$ To match accelerations at points C, $\frac{2C_0 L_3}{(\beta_3)^2} = \frac{\pi^2 L_3}{2(\beta_2)^2}$ where $C_0 = 2.63415$

* See Figs. 6, 7, and 8 for meaning of designation C5, H6, etc.

end of the dwell is matched by selecting a curve having zero acceleration at the start of the rise. The acceleration required at the end of the rise is determined by the succeeding condition. If a fall follows immediately, the rise can end in a fairly high value of deceleration, because this can be matched precisely by a curve having the same deceleration for the start of the fall. This technique of matching accelerations is termed the "Method of Profile Synthesis" and is illustrated by Table I.

Selection of profiles to suit particular requirements is made according to the following criteria:

1. The cycloid provides zero acceleration at both ends

of the motion. Therefore, it can be coupled to a dwell at each end. Because pressure angle is relatively high, and acceleration returns to zero unnecessarily, two cycloids should not be coupled together.

2. Of the three curves, the harmonic provides the lowest peak acceleration and pressure angle for a given rise. Therefore it is preferred when the acceleration at both start and finish can be matched to the end acceleration of the adajcent profiles. Because acceleration at the midpoint is zero, the half-harmonic can often be used where a constant-velocity rise follows an acceleration. Alternately, the half-harmonic could be coupled to a half-cycloid or a half-polynomial.

3. The eighth-power polynomial provides a peak acceleration and pressure angle intermediate between the harmonic and cycloid. Its non-symmetrical acceleration characteristics can be very useful.

For example, the zero acceleration at the start of a rise or conclusion of a fall can be coupled to a dwell. Similarly, the finite acceleration at the end of the rise permits coupling to a harmonic or to the start of a polynomial fall.

Other useful polynomial curves have been developed (Ref 5) but the labor of fitting to a given cam requirement may be forbiddingly complex unless complete tables of values are at hand. When high speed computing equipment is available, it is feasible to develop and fit special polynomials when the standard functions do not provide the desired characteristics.

NUMERICAL DISPLACEMENT DATA

Point by point displacement data are given in Tables II, III and IV which are presented as Reference Sheets on pages 211, 213 and 215. These data, which will minimize the work in preparing cam drawings, are essentially dimensionless, with the angle θ going from 0 to 60 while y goes from 0 to 1. To determine increments corresponding to specific values of β and L, tabulated values of θ are multiplied by the ratio $\beta/60$ and corresponding values of y are multiplied by L.

Sixty divisions were selected for θ because this yields angular increments in integer values of minutes of arc. For example, if β were 29 deg, each increment would be 29/60 deg, or 29 minutes. If every other point were used, then the increment would be 29/30 deg, or 58 minutes.

Two examples are given below to demonstrate the solution of cam problems using the figures and tables.

PROBLEM 1 — Cyclical Fall, Rise, Fall, Rise (scotch yoke motion, Fig. 9). This displacement and velocity requirements are:

Point A	Point B	Point C
$y = L$	$y = 0$	$y = L$
$v = 0$	$v = 0$	$v = 0$
a = (not specified)		

This condition is met most satisfactorily by the harmonic profile. Jerk is not a problem because the continuous cycling of rise and fall permits matching of accelerations at the end of each cycle. Referring to Fig. 7, profile **H6** is selected for curve AB and profile **H5** for curve BC. β_1 must be set equal to β_2 to match accelerations at point B.

Using Table III on page 213, increments are obtained for cam cutting as follows:

For each angular increment $\theta\beta_1/60$ or $\theta\beta_2/60$, obtain a corresponding value of y by multiplying the total lift L by the value given in Table III (column **H6**).

	Angular Increment	y	$R = R_0 + y$
Curve AB	0	1.000000	$R_0 + L$
	$\beta_1/60$	0.999315	$R_0 + 0.999315\,L$
	$2\beta_1/60$	0.997261	$R_0 + 0.997261\,L$
	$3\beta_1/60$	etc.	etc.

This computation can be made rapidly with a desk calculator, although the basic tabular data for each cam profile can be preserved in the form of a deck of punched cards. When a new cam calculation is desired, results are then obtained in seconds.

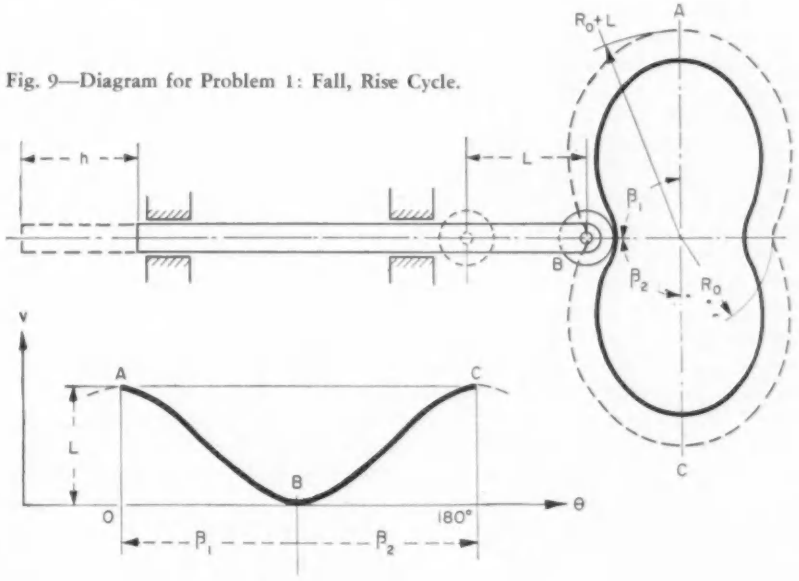


Fig. 9—Diagram for Problem 1: Fall, Rise Cycle.

PROBLEM 2—Dwell, Rise (acceleration), Rise (constant velocity), Rise (deceleration), Fall, Dwell, Fig. 10. This mechanism is widely used in calculating equipment to pick off a punched card from the stack. After initial acceleration to the peripheral velocity of the feed rolls, the picker knife proceeds at constant velocity until the feed rolls pick up the card. The picker knife then decelerates and returns to the starting point. Requirements are:

Point A	Point B	Point C	Point D	Point E
$y=0$	$y=L_1$	$y=L_1+L_2$	$y=L_4$	$y=0$
$v=0$	$v=v_{cv}$	$v=v_{cv}$	$v=0$	$v=0$
$a=0$	$a=0$	$a=0$	$a=a_d$	$a=0$

Curve selections are:

AB—use half-cycloid C_1 to provide zero acceleration at A, the connection with the dwell and at *B*, the connection with the constant velocity portion.

BC—constant velocity.

CD—use half-harmonic **H2**, coupling at *C* to the constant velocity section with zero acceleration and

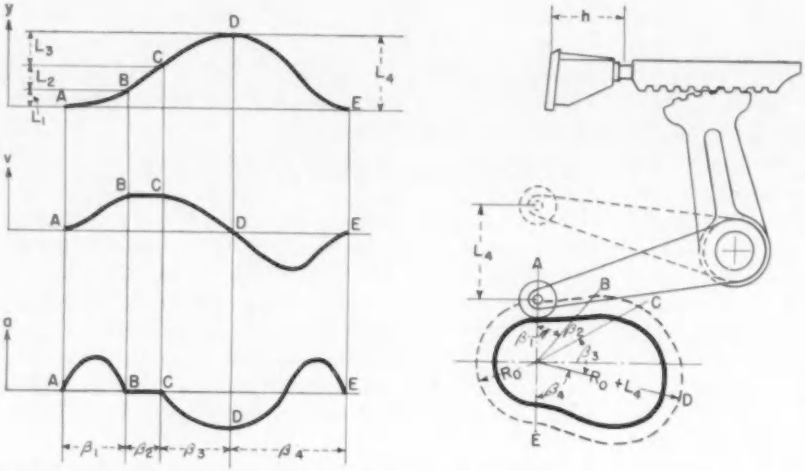


Fig. 10—Diagram for Problem 2: Dwell, Rise (accelerate), Rise (constant velocity), Rise (decelerate), Fall, Dwell.

providing minimum pressure angle over the rest of the curve.

DE—use polynominal **P2** to match the deceleration of the harmonic at *D* and to provide a zero acceleration juncture with the dwell at *E*.

Calculations include:

1. $L_4 = L_1 + L_2 + L_3$
2. The velocity of the constant velocity portion *BC* is $v_{cv} = L_2/\beta_2$
3. To match velocities at Point B, $2L_1/\beta_1 = L_2/\beta_2$
4. To match velocities at Point C, $(\pi/2)(L_3/\beta_3) = L_2/\beta_2$
5. To match accelerations at point D
   $(\pi^2/4)[L_3/(\beta_3)^2] = 5.2683[L_4/(\beta_3)^2]$
   $\beta_1+\beta_2+\beta_3+\beta_4 =$ total angle specified.

L_1, L_2 and L_3 and v_{cv} are known; thus β_1, β_2, β_3 and β_4 can be computed.

Following the procedure of Problem 1, a point-by-point cam lift chart can be prepared by use of the appropriate tables. Because the follower does not move radially but swings in an arc, however, the movement *h* of the picker knife will not be precisely cycloidal during angle β_1, and similar distortions are introduced in the other curves. Although there is a small error, the acceleration characteristics are essentially preserved.

The error will be unimportant where the motion of the follower is nearly radial and the lift is small compared to the length of the follower arm; however, when this is not the case, the problem is solved by trigonometric methods, preferably aided by use of automatic computing equipment. This approach will be discussed in a later installment, which will also consider solution of other special cases such as the offset radial follower.

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3. "Designing Cams," C. N. Neklutin, *Machine Design*, Vol. 24, June 1952, pp 143-160.

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5. "Polydyne Cam Design," D. A. Stoddart, *Machine Design*, Vol. 25, January, February, March 1953, pp 121-135, 146-154, 149-164.

EDITOR'S NOTE: This is the first of a series of articles that will be devoted to cam design. The next installment will give data for making a quick check on the maximum pressure angle, prior to laying out the cam.

Machine Tools for the Jet Age

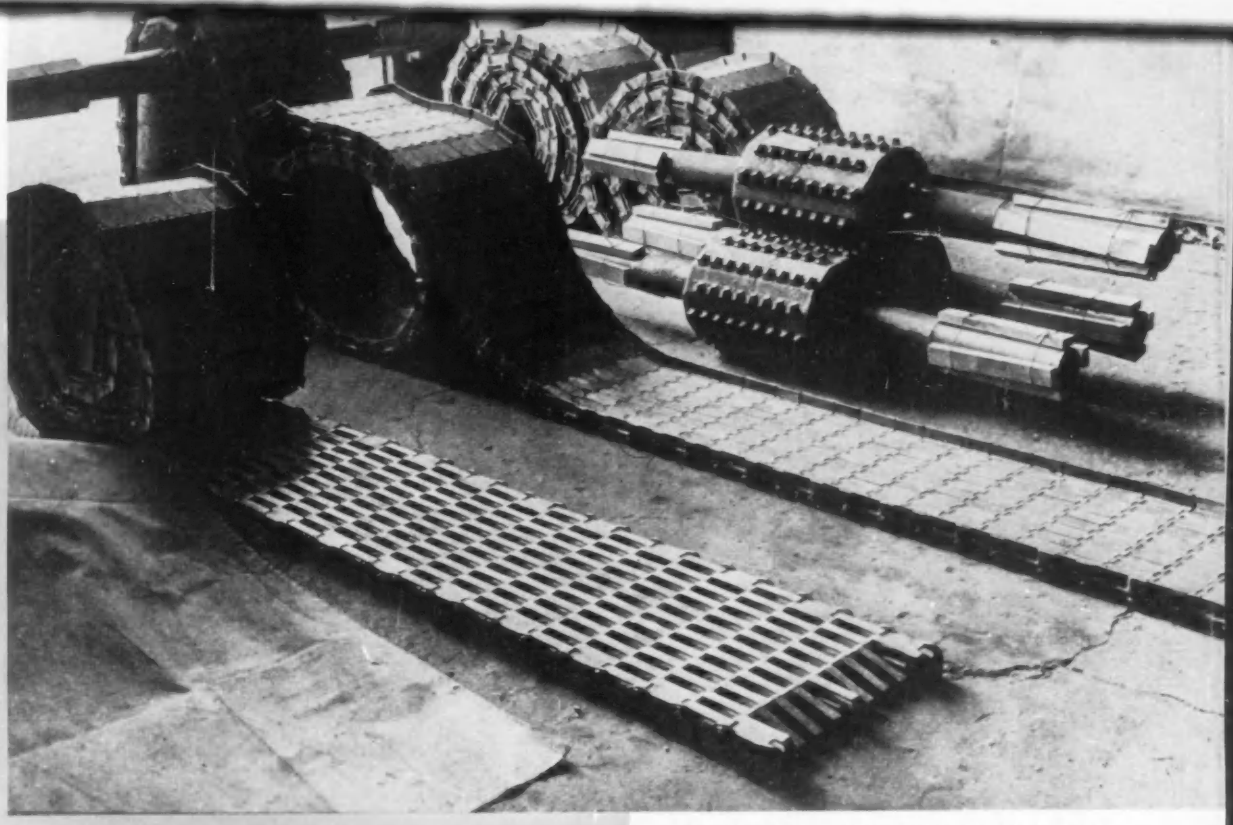
THE COMPLEXITY OF THE AIRCRAFT being built today require more machined parts than ever before. As a result, the Manufacturing Methods Committee of the Aircraft Industries Association feels that larger, more powerful, and more adaptable machine tools will be needed before the current aircraft program can be carried out. A recent meeting by The Machine Tool Panel of this Committee revealed that as soon as the quotations and other paper work is processed, the orders for these new machines will be placed.

One aim of the program is to make individual tools more adaptable to a variety of conditions and uses. An effort is being made to reduce the large number of types; increase the ranges of speed feeds; get easier set-ups; and permit easier adjustments during the manufacture of a part. It was noted that in present milling machines, it is necessary to move the part from machine to machine as different cuts are made. With complicated aircraft parts requiring many cuts, such a process is not practical.

As an example, skin mills and spar mills have been special purpose tools. The new change is an attempt to standardize both in two different widths, extendable in length. The AIA also wants to make it possible for a company to buy a machine for one use, and later convert it to a new use by adding several components. Also, in present day mills, maximum spindle speed is about 1,500 rpm. When used on aluminum or magnesium, it is not able to feed fast enough. The newer machines will up the feeding rate two to three times.

It was predicted that the cost of the new machines would not be prohibitive, and that they will save money in the long run. For a standard milling machine, it was estimated that, after production is under way, the cost will be the same as current models. There will be a third to one-half saving in actual cutting time when working with magnesium. And, when tooling up a new plant, it will cost less with the new machines, because of the fewer, more versatile machines.

A spokesman for the AIA says that the trend from sheet metal to machined parts has put the aircraft industry in a position of not being able to cope with the large scale production that is necessary. Furthermore, the new tools will be useful to subcontractors as well. Because of the machine's versatility, it will give the subcontractor greater adaptability.



BELT and sprockets for hardening furnace conveyor, temperatures 1400-1700 F. Average life, 1 year, when cast of HU (39 percent Ni-19 percent Cr) alloy. Specially designed driving sprocket transmits the pull evenly across the entire belt width.

Heat Resistant Cast High Alloys

Metals specified for service at elevated temperatures must be resistant to hot gas corrosion and withstand the stresses encountered during heating and cooling cycles. Do not overlook the cast Fe-Cr-Ni alloys for these applications. Here is a special series of cast alloys widely used for industrial processes operating above 1200 F.

C. K. LOCKWOOD

President, Alloy Casting Institute
Mineola, N. Y.

IMPORTANT METAL COMPONENTS are being designed for continuous or intermittent service at temperatures as high as 2,150 F. The design of such equipment is complicated by hot gas corrosion which causes progressive scaling of conventional structural materials to an extent that reduces the sectional area of an exposed part, with consequent loss of load-carrying ability.

Under these conditions the plain carbon and low alloy steels do not normally give satisfactory service and the iron-chromium-nickel high alloys are being specified for such applications. These materials are usually referred to as heat resistant alloys and are similar to the familiar stainless steels. There are more cast than wrought grades available because the inherent high hot strength of these alloys makes them difficult to forge or roll.

Cast iron-base or nickel-base high alloys should not be confused with the so-called "super alloys" developed during the war.

These are nickel-molybdenum and cobalt-base alloys which are used mainly for special applications in the jet engine field. Because of the amounts of costly elements in the super alloys they are more expensive than the iron-chromium-nickel high alloys, and this restricts their applications.

Castings used for industrial high temperature service are made from a group of ferrous materials containing nickel and chromium in amounts that constitute 8 per cent or more of the total composition. As defined by the Alloy Casting Institute, the heat resistant cast high alloys are generally used under conditions where the metal temperature is in excess of 1,200 F, in a wide range of atmosphere and stress conditions.

Cast alloys are made to somewhat different chemical specifications than wrought alloys. Physical and mechanical properties for each group also differ. For these reasons it is advisable to follow the standard ACI designations

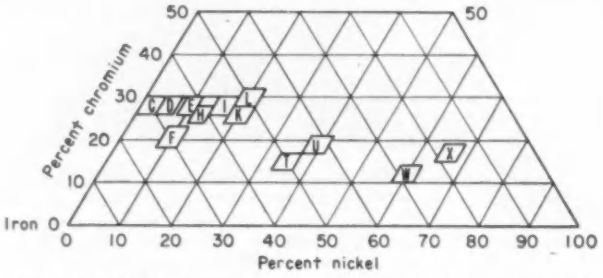


Fig. 1—Location of cast heat resistant standard grades in iron-chromium-nickel system.

for cast high alloys, just as AISI designations are used for wrought materials. In many applications at high temperatures, cast alloys have properties superior to those of corresponding wrought grades.

As shown in Fig. 1, heat resistant cast alloys fall under three general classifications:

CLASS I—Iron-chromium alloy castings containing 18 to 30 per cent chromium. These alloys are used chiefly for resistance to oxidation, as they have low strength at elevated temperatures. The chromium content is dictated by the service temperature, the chromium content increasing with increasing temperature. These alloys are ferritic.

CLASS II—Iron-chromium-nickel alloy castings containing 18 to 32 per cent chromium and 8 to 22 per cent nickel, with chromium always exceeding nickel content. These alloys are partially or fully austenitic, and have greater strength and ductility in service than the iron-chromium group. These alloys can be used in sulfur, oxidizing, and reducing atmospheres.

CLASS III—Iron-nickel-chromium alloy castings containing 33 to 68 per cent nickel and 10 to 21 per cent chromium. These alloys are fully austenitic and have high strengths at elevated temperatures. Although the high nickel content makes Class III alloys unsuitable for use in the presence of appreciable sulfur, these alloys give excellent service in chemically reactive media and under conditions involving thermal shock.

Before a part can be designed for elevated temperature application, and the alloy selected, the expected use and service conditions must be considered. Room temperature tensile and yield strength may mean very little, for example, for a part that is to operate at 1,800 F in a reducing atmosphere. The *minimum* room temperature mechanical property values for standard heat resistant cast high alloy grades are in accordance with ASTM Spec. No. A-297-49T. Such room temperature values indicate only whether the alloy is sufficiently strong to withstand assembly and handling before being placed in its end-use.

Considerations for Specification

Service temperature is one of the many considerations which must be known before a suitable alloy may be specified for the job. Other considerations are:

1. Is the temperature steady or cycling?
2. Type of atmosphere (oxidizing, reducing, sulfur or carbon-containing).
3. Magnitude and type of stresses.
4. Function of the part and its required surface life.

With this information, the alloy or group of alloys that meet the requirements can be determined. The important properties to be considered at elevated temperature are hot strength, thermal expansion, structural stability, corrosion resistance, resistance to thermal fatigue, and hot ductility.

One of the first properties to consider is the strength of the alloy at the service temperature, as well as its ductility. There are three types of tests that are used, usually in combination, to obtain strength data. The short-time elevated temperature test, in which a standard tensile test bar is heated at a designated uniform temperature for one hour and then pulled while at temperature is used mainly to determine the maximum short-time overload that could be sustained without fracture. Since this test does not indicate the extent of plastic deformation to which the castings are subject in long-time service, the stress value obtained can be used only to a limited extent for design purposes.

Creep Characteristics

Since all materials do not creep at the same rate or the same temperature, this property must also be determined. A creep test involves the periodic measurement of the elongation of a specimen held in an electric furnace at a given temperature while under a constant tensile load. Testing time is frequently from 1,000 to 3,000 hr, but longer periods are sometimes used. The purpose of the creep test is to determine the stress that will result in a given creep rate. Creep strength is usually expressed as stress to produce a creep rate of 0.0001 per cent per hour, or one per cent per 10,000 hours. This is sometimes referred to as LCS or limiting creep stress. Table I lists representative creep strength values for standard heat resistant cast high alloys.

The stress-rupture test serves to supplement creep test data. Heavier loads are used, thus causing greater deformation, and the specimen is tested until it fails. Stress-rupture values usually are reported as stress to fracture in 100 or 1000 hours. Results obtained from this test are valuable for showing load carrying ability and for indicating hot ductility up to fracture as well as the degree of surface and

Table I—Representative Creep Strength Values for Cast Heat Resistant Alloys[a]

ACI Type	Cr percent	Ni percent	Stress for Creep Rate of 0.0001 percent/hr, psi[a] 1400 F	1600 F	1800 F	2000 F
HC[b]	28	(4)	1,300	750	360	.....
HD	28	5	3,500	1,900	900	.....
HE	28	10	3,500	2,000	1,000	.....
HF	20	10	6,000	3,200	.....	.....
HH[c]	26	12	3,000	1,700	1,100	300
HH[d]	26	12	7,000	4,000	2,100	800
HI	28	15	6,600	3,600	1,900	800
HK	26	20	6,800	4,200	2,700	1,000
HL	30	20	7,000	4,300	.....	.....
HT	15	36	8,000	4,500	2,000	500
HU	19	39	8,500	5,000	2,200	600
HW	12	61	6,000	3,000	1,400	.....
HX	17	67	6,400	3,200	1,600	600

[a] Values represent constant-temperature operation. If alloys are exposed to cyclic temperatures, lower values would apply.
[b] Alloy with more than 2.5 per cent Ni and 0.15 per cent N.
[c] Partially ferritic (ASTM B190, Type I).
[d] Wholly austenitic (ASTM B190, type II).

Table II—Rupture Strength of Cast Heat Resistant Alloys[a]

ACI Type	Stress at Rupture, psi 1,400 F		1,600 F		1,800 F		2,000 F	
	100 hr	1,000 hr	100 hr	1,000 hr	100 hr	1,000 hr	100 hr	1,000 hr
HC[b]	3,300	2,300	1,700	1,300	1,000	620	.....	.....
HD	10,000	.....	5,000	.....	2,500	.....	.....	.....
HE	11,000	.....	5,300	.....	2,500	.....	.....	.....
HF	14,000	8,000	6,000	3,800	.....	.....	.....	.....
HH[c]	14,000	6,500	6,400	3,800	3,100	2,100	1,500	.....
HH[d]	14,000	10,000	7,500	4,700	4,000	2,500	1,800	1,200
HI	13,000	8,500	7,500	4,800	4,100	2,600	1,900	1,250
HK	14,500	9,000	7,800	5,000	4,500	3,000	2,500	.....
HL	15,000	.....	9,200	.....	5,200	.....	.....	.....
HT	18,000	12,500	8,500	7,000	4,500	3,700	2,500	1,800
HU	15,000	.....	8,000	6,000	4,500	2,900	.....	.....
HW	10,000	7,800	6,000	4,500	3,600	2,600	.....	.....
HX	13,000	.....	6,700	4,000	3,500	2,200	1,700	900

[a] Values represent constant-temperature operation. If alloys are exposed to cyclic temperatures, lower values would apply.
[b] Alloy with more than 2.5 per cent Ni and 0.15 per cent N.
[c] Partially ferritic (ASTM B190, type I).
[d] Wholly austenitic (ASTM B190, type II).

structural stability under test conditions. It shows the influence of time, temperature, and stress on the ductility up to fracture. Table II gives rupture strength values for standard heat resistant cast high alloy grades.

Dimensional Stability

Dimensional stability during heating and cooling cycles must be taken into consideration. Hence, the thermal coefficient of expansion is another item that is important. Clearances for moving parts require careful consideration in high temperature service, because of the changes in dimensions resulting from exposure to elevated temperatures.

Strength data obtained from laboratory tests are not enough in themselves for design purposes. High temperature tests and test methods still contain many unknown variables. Allowable design stresses are usually based on the experience of the user and producer. Design values, or factors of safety, vary widely, depending on service conditions. A rule of thumb often used is that design stresses can be 50 percent of the limiting creep stress. Where temperatures or loads are cycling, the permissible working stresses must be lower. The load carrying ability

can be reduced by a factor of ten if the constant temperature of a creep test is reduced to room temperature once every day. Parts that are built into a permanent structure must be designed with more caution than those that can be easily replaced.

Cast High Alloys

IRON-CHROMIUM GROUP. In this class of heat resistant alloys, there are three ACI designated types—HB, HC, and HD. The type HB alloy, with 18 percent chromium, is not considered a "standard grade" and is useful only up to 1,500 F. Because of its low strength at high temperatures, it has limited application. Types HC (26-30 Cr, 4 max Ni) and HD (26-30 Cr, 4-7 Ni) can be used for load bearing applications up to 1,200 F, and where only light loads are involved, up to 1,900 F, because of its higher nickel content, type HD has a somewhat greater strength at elevated temperatures. These types are useful in high sulfur atmospheres. The HC alloy is supplied in two carbon ranges: up to 0.50 per cent for normal high temperature service, and up to 3.0 per cent where an abrasion resistant material is required. Types HC and HD are used in ore roasting furnaces for parts such as rabble arms and blades; they are also used for salt pots, grate bars, and high sulfur atmosphere applications not requiring high strengths.

IRON-CHROMIUM-NICKEL GROUP. These alloys, types HE, HF, HH, HI, HK, and HL, being partially or completely austenitic, have greater high temperature strength and ductility than the iron-chromium alloys. They can be used in either oxidizing or reducing atmospheres. Type HF alloy (19-23 Cr, 9-12 Ni) is similar in composition to the 18-8 stainless steels used for their corrosion resistance except that carbon content is higher. This alloy can be used at temperatures up to 1,600 F. Type HF castings operate in the 1,200 to 1,600 F temperature range in oil refineries for tube supports and beams, in cement mill parts, ore roasting furnace parts and in heat treating furnaces.

Type HE (26-30 Cr, 8-11 Ni) has a higher chromium content than type HF, which makes it suitable for service up to 2,000 F. This alloy has excellent corrosion resistance at high temperatures. It is stronger and more ductile than the straight chromium types at room temperature. At elevated temperatures it has good ductility and moderate strength. Its relatively low nickel content makes it readily applicable for use in high sulfur atmospheres where moderate strength is required. Typical applications are in ore roasting furnaces, steel mill furnaces, and carrier blades.

Type HH (24-28 Cr, 11-14 Ni) exhibits high strength and resistance to oxidation at temperatures up to 2,000 F. These properties make it a useful alloy, and it accounts for about one-third of the production of all heat resistant castings. Depending on the composition, the alloy can be partially ferritic or fully austenitic.

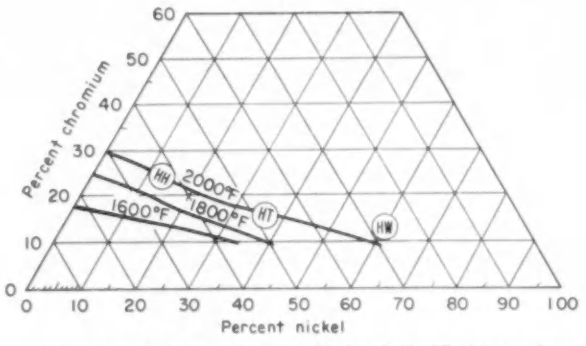
The partially ferritic alloy has lower creep strength and higher ductility at elevated temperature than the austenitic alloy. Between 1,200 and 1,600 F the ferritic alloy may developed a weak intermediate structural phase called sigma; thus, the austenitic type should be used if operation will be in this temperature range. The selection of a type HH alloy, therefore, must be tailored to the application. For service above 1,600 F, either of the compositions will serve. Typical applications for the HH type of alloys are as tube supports and beams in oil refineries, ore roasting furnace parts, and heat treating parts. They are not generally recommended for service where severe temperature cycles are encountered, such as in quenching fixtures.

Type HI (26-30 Cr, 14-18 Ni) with higher nickel and chromium content than type HH, is more resistant to oxidation and can be used up to 2,150 F. Although similar to the HH alloys in mechanical properties and composition sensitivity, it is more likely to be austenitic. Cast retorts for magnesium production have been the major application for this grade.

Type HK (24-28 Cr, 18-22 Ni) with still higher nickel content than type HI, is similar to a fully austenitic HH alloy. This alloy has high resistance to oxidation and is one of the strongest heat resistant cast alloys at temperatures above 1,900 F. It can be used in structural applications up to 2,100 F. Type HK resists hot gas corrosion somewhat better than type HH. It is not recommended for high sulfur atmospheres, or where severe thermal shock is a factor, but is widely used for parts where high creep strength is needed, such as jet engines, gas turbines, furnace parts and chain.

Type HL (28-32 Cr, 18-22 Ni) is similar to type HK but with higher chromium content. Because the composition of this alloy is the most resistant of the group to corrosion in high sulfur atmospheres up to 1,800 F, it is adapted for use where higher strength is required than obtainable with straight chromium alloys. Typical uses are for gas dissociation equipment fixtures.

NICKEL-CHROMIUM-IRON GROUP. These alloys, types HT, HU, HW, and HX, employ nickel either as the predominant alloying element, or actually as the base metal. As a result, these alloys have a stable austenitic structure and are not as sensitive to variations in composition as the high chromium grades. This high-nickel group normally constitutes about 40 per cent of the total production of heat resistant castings. They can be used for almost all applications up to 2,100 F, and give excellent service



Brasunas, A. deS., Gow, J. T., and Harder, O. E., "Resistance of Iron-Chromium-Nickel Alloys to Corrosion in Air at 1,600 to 2,200 F", *Proceedings*, ASTM, Vol. 46, pp 129-160, 1946.

Fig. 2—The minimum nickel and chromium contents for a maximum metal loss of 0.050 inch per year by air corrosion at 1,600, 1,800 and 2,000 F based on 100-hr tests. Alloys also contain about 0.4 C, 1.25 Si, 0.75 Mn, bal. Fe.

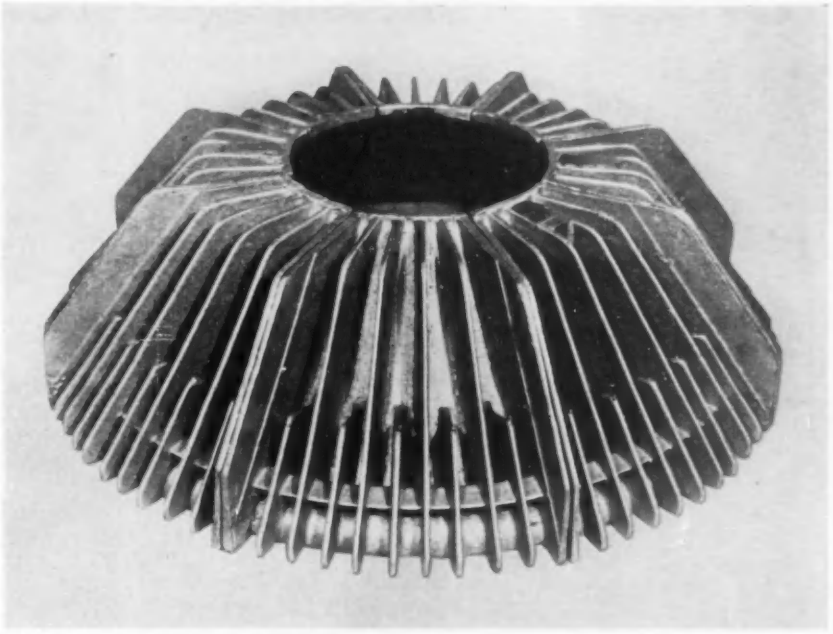
life where subject to rapid heating and cooling. Because of their high nickel content however, they are not recommended for use in high sulfur atmospheres. In selecting alloys from this group, the following factors are important:

1. Increasing nickel content increases resistance to carburization, decreases hot strength somewhat, and increases resistance to thermal shock.

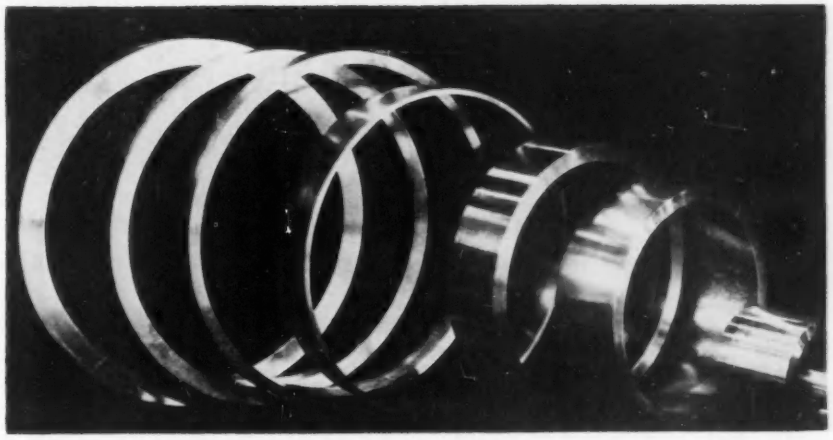
2. Increasing chromium content increases resistance to corrosion and oxidation. Fig. 2 shows effect of nickel and chromium contents on metal loss from air oxidation at elevated temperatures.

3. Increasing carbon content increases hot strength.

4. Increasing silicon content increases resistance to carburization, but decreases hot strength.



OIL OR GAS BURNER DEFLECTOR, for temperatures up to 2000 F. Assembled by welding without machine faces. Produced in HK alloy (25 per cent Cr—20 per cent Ni). Approximately 30 in diameter.



CENTRIFUGALLY CAST high alloy jet aircraft engine rings. These castings must resist elevated temperatures and must be free from surface or internal defects. Special modification of HH alloy containing 22 per cent chromium, 14 per cent nickel with additions of tungsten. Weight, 150 to 500 lb each.

Type HT (33-37 Ni, 13-17 Cr) can be used satisfactorily at temperatures up to 2,100 F in oxidizing atmospheres, and 2,000 F in reducing atmospheres. This alloy is used for about one-third of all the heat resistant castings produced. Where carburization must be kept to a minimum, silicon should be not less than 1.25 percent. Type HT alloy is used widely for heat treating furnace parts such as rails, rolls, disks, chains, boxes, pots, and fixtures subject to cyclic heating. It is used also for glass rolls, enameling racks, and radiant heater tubes.

Type HU (37-31 Ni, 17-21 Cr) is recommended for severe service conditions because of its high hot strength. The higher chromium content also increase resistance to corrosive attack.

Type HW (58-62 Ni, 10-14 Cr) is used for applications in oxidizing atmospheres up to 2,050 F, and in reducing atmospheres up to 1,900 F. It is used extensively for parts that require resistance to oxidation, carburization, nitriding, and thermal shock. Its high electrical resistivity makes it suitable for use as cast electrical heating elements. It is not recommended for use in high sulfur hot gases. Typical uses are for severe service at high temperatures involving cyclic heating or thermal shock. Applications are hearths, muffles, retorts, trays, boxes, burner parts, enameling fixtures, quenching fixtures, and containers for molten lead.

Type HX (64-68 Ni, 15-19 Cr) is more resistant to corrosion at elevated temperatures than type HW, because of its higher nickel and chromium content. It is considerably better than type HW in resistance to reducing gases containing sulfur at 1,800 F. Both HW and HX alloys are highly resistant to carburization when in contact with tempering and cyaniding salts. They are not recommended for use with neutral salts, however, or salts used in hardening high speed steels. Type HX is used for the same applications as type HW where improved resistance to hot gas corrosion is required.

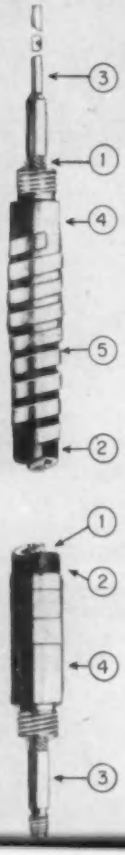
EDITOR'S NOTE—This article supplements the information given by J. R. Lane, "Strength of Cast Alloys at 1,200 F," *Product Engineering*, June 1954.

FLEXIBLE SHAFTS

For Power Drives and Remote Control:

. . . Allow freedom in locating components
. . . Connect shafts having relative motion
. . . Eliminate dangerously exposed rotating parts
. . . Do not require accurate alignment.
. . . Replace connections affected by vibration

C. HOTCHKISS, JR.
Application Engineer, Stow Manufacturing Co.



FLEXIBLE SHAFT TERMINOLOGY

FLEXIBLE SHAFT— Combination core and casing assembly

CORE ASSEMBLY— Core with fittings

CASING ASSEMBLY— Casing with ferrules

1. CORE— Core only, without fittings
2. CASING— Casing only, without ferrules
3. FITTINGS— Terminals attached to the ends of a core
4. FERRULES— Terminals attached to the end of a casing
5. REINFORCEMENT— External steel winding for additional casing support

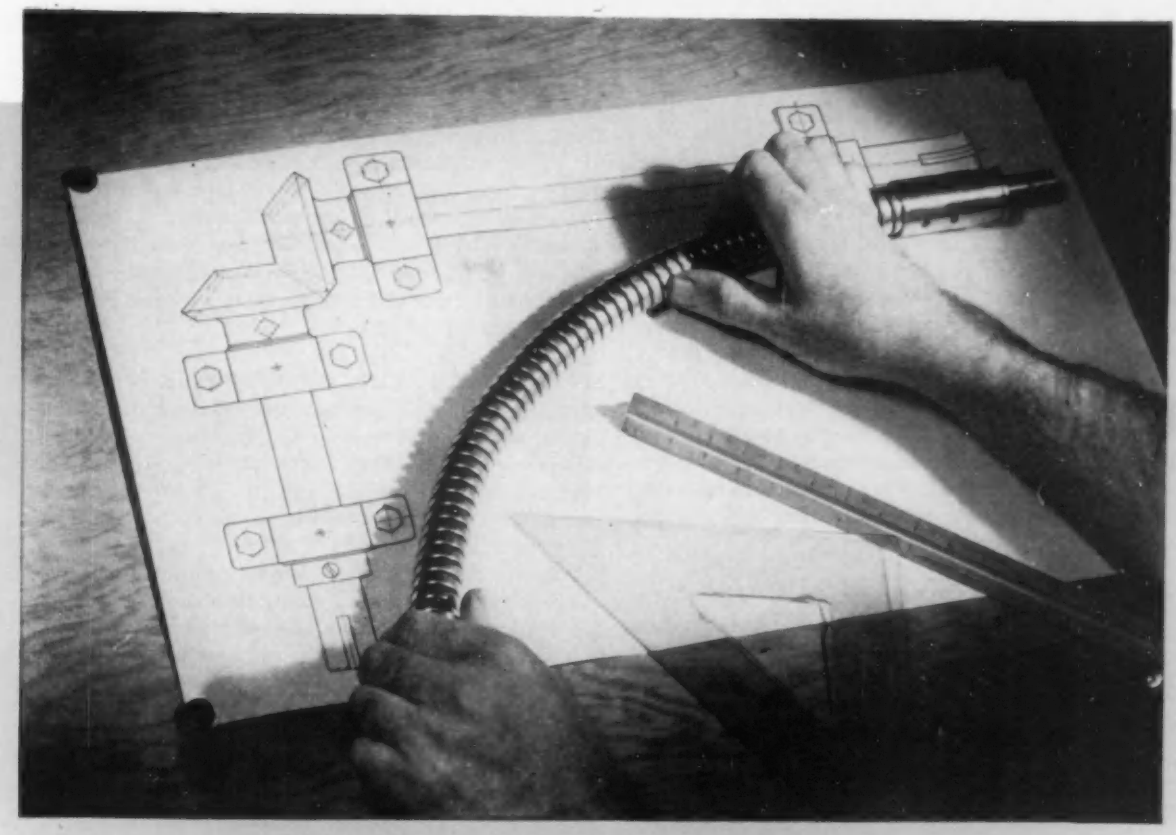
Fig. 1

APPLICATION OF FLEXIBLE SHAFTS can be divided into two major types: (1) power drives—where speed, operating conditions, direction of rotation, length as well as torque are factors in the design; and (2) remote controls—where speeds are low and only torque is considered.

For both types of application, the method of selecting the correct flexible shaft is the same—first, the core, then the casing and, finally, the proper end terminal.

CORE CONSTRUCTION AND SELECTION FOR POWER DRIVES

Cores, Fig. 2, can be classified as follows: (1) those for applications where no heavy shock loads are encountered. These are produced on automatic high-speed winding machines and therefore are lowest in cost; (2) cores for good shock absorption and long life but which are not recommended for lengths less than 25 diameters; and (3), custom-built cores where high shock absorption and long life are necessary. Also, they can be used in short lengths and



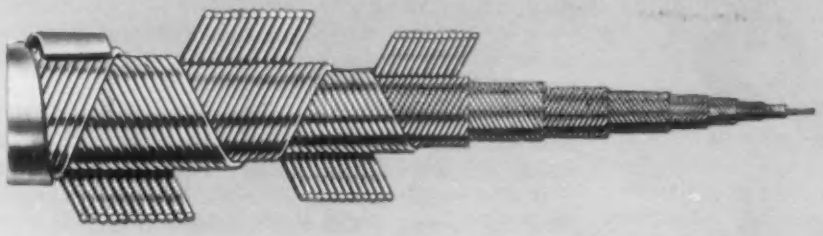


Fig. 2—Cores are classified as follows: low cost units made from a combination of low-carbon and high-carbon wire; produced on automatic high speed winding machines. Medium cost cores made from music wire with a high carbon center on semi-automatic machines; high cost cores that can be cut without unravelling.

are recommended for all high speed applications.

The following factors must be considered in selecting the correct core: *torque to be transmitted, operating speed, bends in the shaft, direction of rotation, life requirements, length, and special operating condition.*

TORQUE. The torque ratings for flexible shafts are based on continuous operation at a given condition. However, starting, stopping, or any suddenly applied torques which exceed the running value may cause permanent distortion of the core. This distortion, which is a permanent kink in the shaft, will cause premature fatigue and breakdown by rubbing against the casing. Therefore, the maximum torque should be used in making the selection. If possible, it should be determined by actual measurement using the following formula:

$$T = \frac{\text{hp} \times 63{,}000}{\text{rpm}}$$

where
T = torque in lb-in.
hp = motor or engine horsepower
rpm = motor or engine speed

OPERATING SPEED. The capacities listed in Table I were determined by noting the torque required to raise the shaft temperature 55 F above ambient while operating at a surface speed of 300 ft per minute. Higher torques than these recommended values will cause further heating which will result in early fatigue. The recommended capacity is the maximum torque that can be transmitted even at speeds slower than specified. At higher speeds, the temperature can be kept constant if the torque is reduced proportionately. The rated speed in rpm equivalent to 300 surface ft per min is shown opposite each shaft in Table I. Therefore, to find the torque capacity of cores operating above rated speeds, multiply the maximum dynamic torque capacity (shown in Table I) by the ratio of rated to operating speed. (see example).

Obviously, the higher the operating speed, the smaller the shaft required to transmit a given torque. Since smaller shafts mean savings in costs, a shaft should be operated at the highest speed which the application will permit. With most shafts, this is limited to about 600 surface ft per min,

double the rated speed. However, for special applications where speeds higher than 600 ft per min are required, a better quality core can be used. Materials and methods of fabrication of these cores are selected to minimize internal friction.

SHAFT BENDS. With respect to bends, there are two types to be considered. The first is with the shaft remaining in a fixed position so that the bends are constant. In the second type, there is relative motion between the driving and driven end. In either instance, the bend with the smallest radius of curvature determines the shaft size. In some instances, if the minimum bend is kept large, a stiffer shaft can be used which may have a higher torque capacity for the same size. The minimum operating radius of curvature, which is the smallest bend at a shaft can be operated without damage, varies with the construction and diameter of the shaft.

DIRECTION OF ROTATING. The layers of wire on a shaft tend to act like springs. Therefore, the shaft must be rotated in the direction that tends to tighten the outer layer on the under layer, Fig. 3. The torque capacity of a shaft in the unwind direction is about 60 per cent of that in the wind-up. For shafts that must rotate in both directions, the torque capacity must be reduced accordingly.

LIFE REQUIREMENTS. Shafts are designed to operate a minimum of 100,000,000 cycles at rated speed and torque at the minimum radius of curvature. Where life is not too important, materials of considerably lower cost can be used. Fatigue life depends primarily on the torque, speed, and operating radius. If a shaft application requires an unusually long life, a larger diameter shaft than would otherwise be required can be used. An alternative is to use a special core made of a higher quality wire and a more expensive method of fabrication.

SPECIAL OPERATING CONDITIONS. The torque ratings given by manufacturers are for cores that are adequately supported along their lengths by clamps approximately every 3 feet. If no clamps are used, the shaft may knot unless a lower torque is applied. Therefore, as a safety factor for unsupported shafts, multiply the calculated torque by 1.6 (see example).

Specified torque ratings are also for continuous operation. When operation is intermittent, these can be exceeded. For example: flexible shafts used to operate the hydraulic mechanism on dump trailers from the power take-off shaft of the truck.

There are also various service factors that must be considered. Besides starting torques, overload torques must be considered. This is especially important where the flexible shaft is not large enough to transmit the full torque of the power source. An example of this is a farm implement driven by a flexible shaft from the power takeoff of the tractor. If a rock or some other obstruction jams the mechanism, the flexible shaft must take the full torque of the engine. To prevent shaft failure on applications of this type clutches or shearing devices should be used.

Another factor is varying loads, such as those encountered with conveyors. Here the flexible shaft must be designed to carry the maximum load the conveyor will handle.

Where flexible shafting is exposed to severe weather conditions, stainless steel or other noncorrosive metal terminals and heavy rubber covered casings are used. In ex-

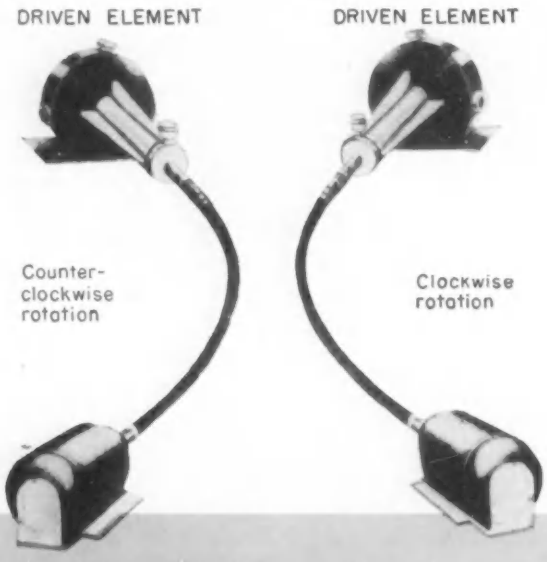
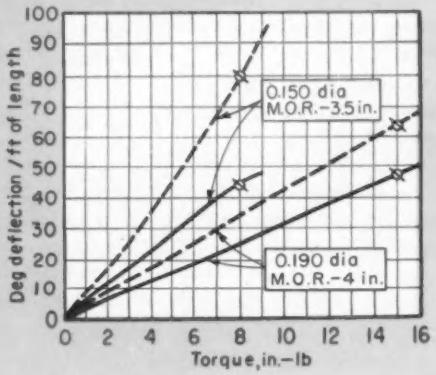


Fig. 3 (Left)—Direction of rotation is always determined from the power or driving element end. Specify left-hand shaft for ccw rotation and right-hand shaft for cw rotation.

Fig. 4 (Right)—Graphs for the selection of remote control cores. Core selected should have its smallest bend larger in radius than the minimum recommended operating radius. To use: find torque and read permissible torsional deflection.

Maximum static torque ratings must not be exceeded. Solid line indicates windup direction. (Windup direction is the direction which tends to tighten the outer layer of wire.) Broken line indicates unwind direction. M.O.R. is minimum operating radius



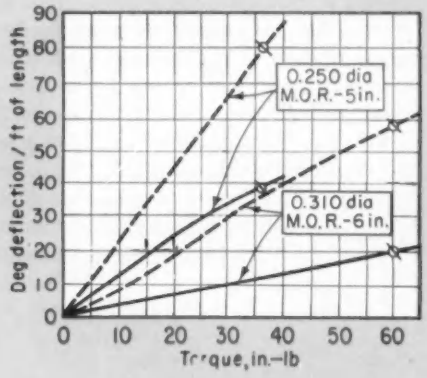


Table I—Maximum Dynamic Torque Capacity (in.-lb)

Rated Speed R.P.M. *	Straight and Curved Shafts — Radius of Curvature, in.											Wgt/ cu ft	Core Dia	Core No. and Type	Shaft Size
	50 to Strgt.	25	20	15	12	10	8	6	5	4	3				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	1.00	0.50	3.0	0.124/0.128	1	13
3,800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	1.5		4.5	0.148/0.152	2	15
2,900	9.4	8.6	8.0	7.6	7.0	6.6	6.0	4.8	3.4	2.0		7.0	0.185/0.189	3	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0			12.5	0.247/0.252	4	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0				20.0	0.308/0.313	5	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8				20.0	0.308/0.313	6	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0			21.0	0.324/0.329	7	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0				28.5	0.368/0.374	8	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0				29.0	0.387/0.393	9	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0				29.0	0.387/0.393	10	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0					50.5	0.497/0.503	11	50
1,150	148	124	110	92	72	56						53.5	0.505/0.511	12	50
900	248	200	176	124	84							78.5	0.610/0.618	13	63
900	220	204	192	180	152	130						80.5	0.630/0.638	14	63
750	340	224	156	76								117	0.747/0.753	15	75
600	760	520	420									205	0.998/1.004	16	100
440	1,500	720										343	1.298/1.304	17	125

* Above the rated speed, torque capacity decreases directly as speed increases.

EXAMPLE—How to use the table:
The problem is to transmit ½ hp at 1700 rpm through an unsupported flexible shaft in a 25 in. radius, estimated starting torque 150 per cent of normal operating torque.

1. Calc. Torque (in-lb)—

$$\frac{\text{hp} \times 63000}{\text{rpm}} = \frac{0.5 \times 63000}{1700} = 18.5$$

2. Correction factor for starting torque $1.5 \times 18.5 = 27.75$

3. Correction factor for unsupported shaft $27.75 \times 1.6 = 44.4$ lb. in.

4. Refer to Table No. 1. Read downward in column under 25 in. radius until you find a core having a rating of at least 44.4 in-lb.

In this case we find that core No. 9 is rated 54 in-lb at 1500 rpm. Since the given speed is 1700 rpm, multiply 54 by 1500 and divide by 1700. $54 \times 1500 \div 1700 = 47.6$ in-lb. (rated torque at 1700 rpm). Therefore, Core No. 9 is correct.

treme cases, such as under-water installations, special leak-proof seals must be used. At very high temperatures the whole shaft including the core must be made of stainless steel. At very low temperatures, a very light grease must be used.

LENGTH. In power drive applications, long lengths up to 30 ft are no problem when selecting the shaft size. Longer lengths can be used but in most instances the cost is prohibitive. Also, special fittings are necessary since the changes in length that occur when a shaft is under load are so great with a long shaft that the fitting may slide out of engagement.

Most length problems involve "too little length." With short shafts, the bend requirements are usually more difficult to satisfy. The stiff length of the end terminals must be subtracted from the total length. If the radius of bend of the free flexible length remaining is smaller than the minimum operating radius of the shaft, some design change must be made so that the bend will not be as sharp. Sometimes universal joints can be used at one end to reduce the bend.

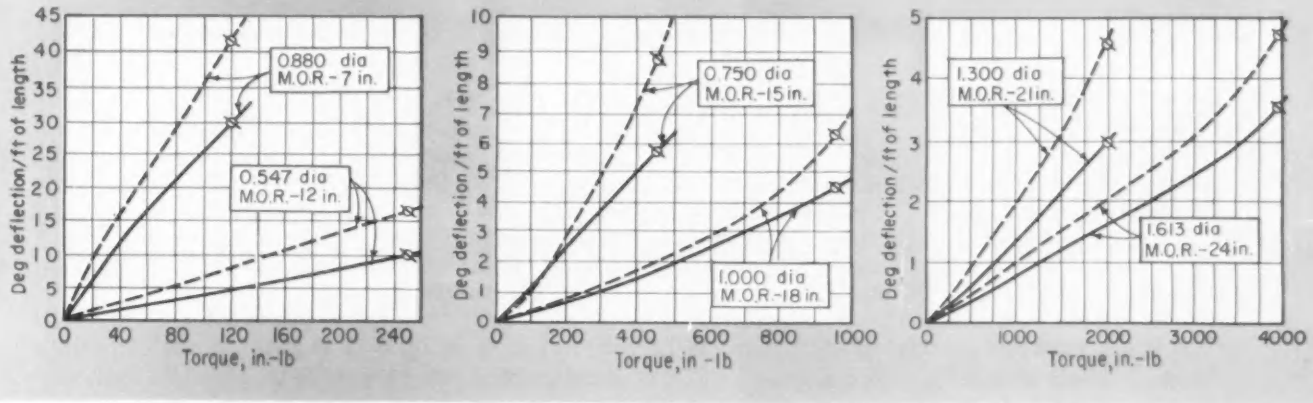


Table II—Flexible Shaft Selection Chart for Remote Valve Control Systems

d = dia of flexible shaft. D = dia of remote station handwheel.

Valve Handwheel Dia. (in.)	Output Torque (ft-lb)	* Length of Remote Control System (ft)															
		5		6–10		11–15		16–20		21–25		26–30		31–40		41–50	
		d	D	d	D	d	D	d	D	d	D	d	D	d	D	d	D
3	10	½	5	½	5	½	5	½	5	½	5	¾	7	¾	7	¾	7
4	13	½	5	½	5	½	5	½	5	¾	7	¾	7	¾	7	¾	7
5	17	½	5	½	5	¾	7	¾	7	¾	7	¾	7	¾	8	¾	8
6	20	¾	7	¾	7	¾	7	¾	7	¾	8	¾	8	1	9	1	10
7	26	¾	8	¾	8	¾	8	¾	8	¾	8	1	10	1	10	1	12
8	30	¾	8	¾	8	1	9	1	10	1	10	1	10	1	12	1	12
9	34	¾	8	1	10	1	10	1	10	1	10	1	12	1	12	1	12
10	40	1	10	1	10	1	12	1	12	1	12	1	12	1	12	1¼	14
11	46	1	12	1	12	1	12	1	12	1	12	1	12	1¼	14	1¼	16
12	50	1	12	1	12	1	12	1	12	1	12	1	12	1¼	16	1¼	18
14	70	1¼	16	1¼	16	1¼	16	1¼	18	1¼	18	1¼	18	1¼	21	1⅝	24
16	80	1¼	18	1¼	18	1¼	18	1¼	18	1¼	18	1¼	21	1⅝	24	1⅝	27
18	90	1¼	18	1¼	18	1¼	18	1¼	21	1¼	21	1⅝	21	1⅝	24	1⅝	27
21	122	1¼	21	1¼	21	1¼	21	1¼	21	1⅝	27	1⅝	27	1⅝	27	1⅝	27
24	140	1⅝	27	1⅝	27	1⅝	27	1⅝	27	1⅝	27	1⅝	27				
27	158	1⅝	27	1⅝	27	1⅝	27	1⅝	27	1⅝	27						

All flexible shafting remote control systems below the heavy line have undersized handwheels, therefore two-man operation is required.

* Where a system consists of more than one flexible shaft, use total length for size selection.

The flexible shaft length for valve controls is calculated as follows: $L = H - (A + R) + \frac{\pi R}{2} + V - (A' + R)$

Table shows the correct flexible shaft sizes (d) and remote station handwheel diameters (D) for various lengths of shafting.

Shafts selected from Table will operate valves with normal effort at the remote station handwheel.

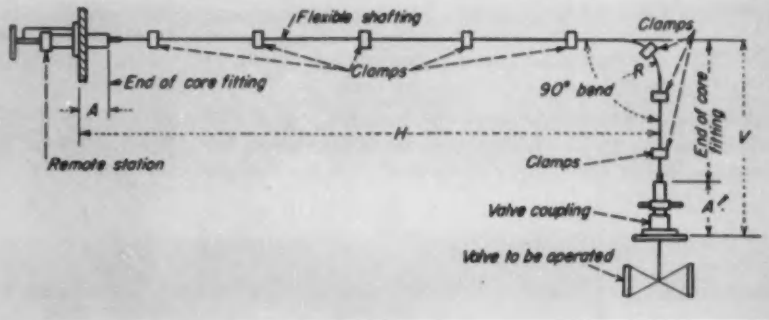


Fig. 5—Typical remote valve control installation. The latter dimensions are used in conjunction with the format of Table II to find shaft size.

SELECTING CORE FOR REMOTE CONTROL

An entirely different method is used in selecting the core for remote control applications. The following factors are considered when selecting the right core from graphs such as Fig. 4 or tables furnished by the manufacturer: the torque required in in.-lb, the total allowable deflection, the radius of curvature of the smallest bend in the shaft.

The torque required to operate the mechanism can be measured by torque wrenches or spring gages.

The total allowable deflection is determined by the type of mechanism being controlled and the degree of accuracy needed to operate it properly. The selected core must have a minimum operating radius (MOR) smaller than the radius of the smallest bend. To select the core, divide the total allowable deflection by the length in feet. This gives the allowable deflection per one foot of length. Where deflection or backlash is the design criteria rather than the torque, the shaft must be larger than would otherwise be required. If great accuracy is needed other means should be used as some backlash is always present in flexible shafting. Next, select the graph, Fig. 4, which has a maximum torque greater than that required. Mark the point

on the graph that corresponds to the torque required and if the deflection per one foot of length is less than computed that is the core size. If not, the next larger shaft must be used. Note that up to 4,000 lb-in. can be transmitted using a 1⅜ in. shaft.

Valve control operation has become one of the most common uses for remote control flexible shafting. For this reason, manufacturers have made up tables (Table II) which make it possible to select the correct size shaft knowing the length of the shaft and the diameter of the valve handwheel. For rising handwheel installations, dimension V, Fig. 5, must be measured with the handwheel at the top of the rise. The valve couplings are designed to telescope for closing.

OTHER DESIGN CONSIDERATIONS

LUBRICATION. Power drive shafts and remote control shafts are lubricated with a light grease—Shell Alvania No. 3 or equivalent. Since the core tends to act like a screw inside the casing in power drive applications, it will eventually force most of the grease down to one end, leaving the other end dry. From time to time depending on speed and amount of use, the shaft should be lubricated to prevent excessive heating.

DISTORTIONS. Breakage of wires near the fitting which is the most common type of failure could be the fault of the manufacturer. The wires might have become brittle when the core was heated while soldering on fittings. More often, however, this breakage is caused by running the shaft with a sharp bend near the end. This means that the wires fatigue by working back and forth against the fitting.

A permanent kink in the core is usually caused by overload. Sometimes, however, it is caused by bending the shaft beyond the minimum radius of curvature. Once the shaft has been overloaded and forms a kink, it will heat rapidly at the point of the kink and may even burn through the casing.

CORE CHANGES. Flexible shaft characteristics can be varied by changing the core diameter, the number of wires per layer, the number of layers of wires, the diameter of the wires in each layer, the spacing between the wires, the material in the wires and the method of fabrication. For instance, cores have been made of ⅜ in. nominal diameter, with the number of layers of wire varying from 4 to 13, the number of wires in the outside layer varying from 4 to 32, and the wire diameter in the outside layer ranging from 0.013 to 0.055 inches.

Also, flexible shafts for power drive applications and for remote control operation differ in construction and deflection. Table III indicates these differences. Remote control shafts are designed to obtain the lowest possible degree of lost motion between the input and output end. Power shafts, however, must be able to withstand fairly high speeds continuously without heating or wearing out.

Power shafts of the same diameter vary also in construction and characteristics. For example, the two size 50 shafts of Table I. The stiffer shaft, both transversely and torsionally, has a higher torque rating in the larger radii of curvature, but at the smaller values the more flexible shaft has the higher rating. The stiffer shaft is not even rated for a 6 in. radius of curvature, for it would break down quickly in fatigue even at low values.

Table III—Variation in Construction and Deflection Of ¼ in. Dia Shafts

	Power Drive	Remote Control
Construction:		
No. of layers	6	8
No. of wires	27	80
Diameter of wires on outside layer (in.)	0.063	0.041
No. of wires on outside layer	6	16
Deflection at 80 in-lb of torque per 1 ft of shaft:		
In direction of windup of outside layer. (deg)	18	3
In direction of unwind of outside layer. (deg)	81	5

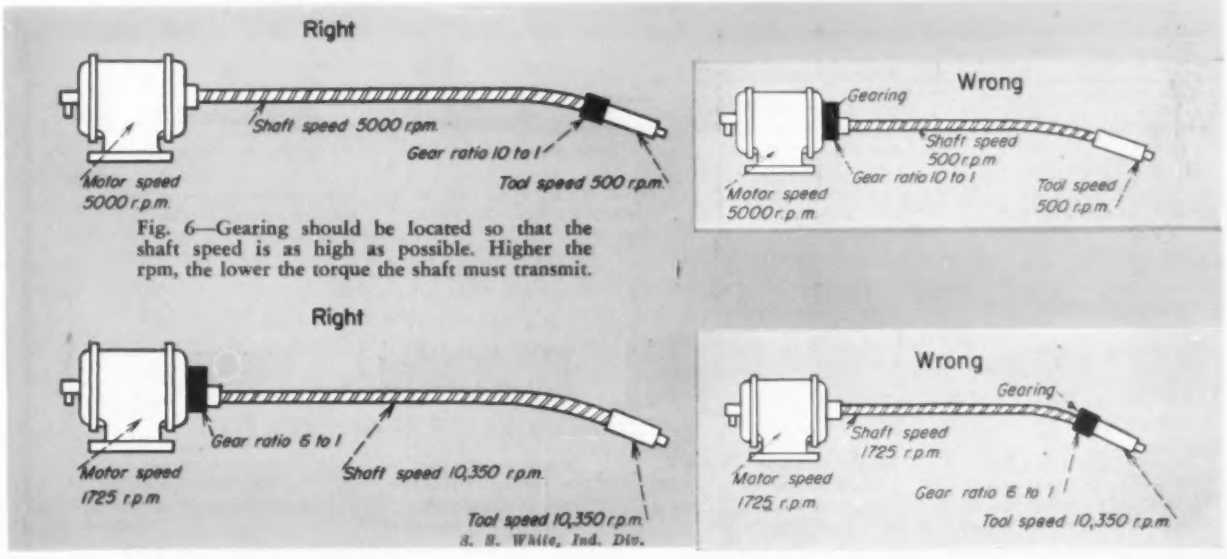
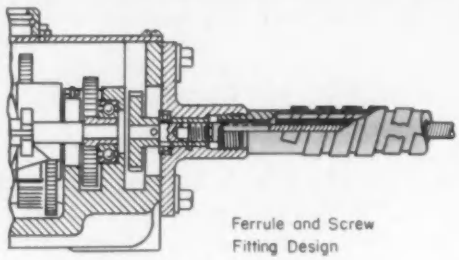
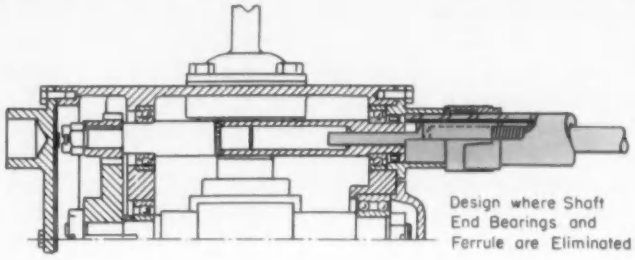


Fig. 6—Gearing should be located so that the shaft speed is as high as possible. Higher the rpm, the lower the torque the shaft must transmit.

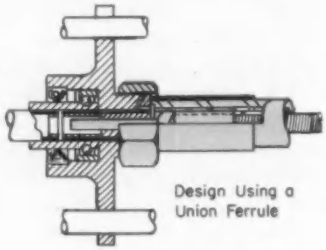
Typical Integral Design Connections



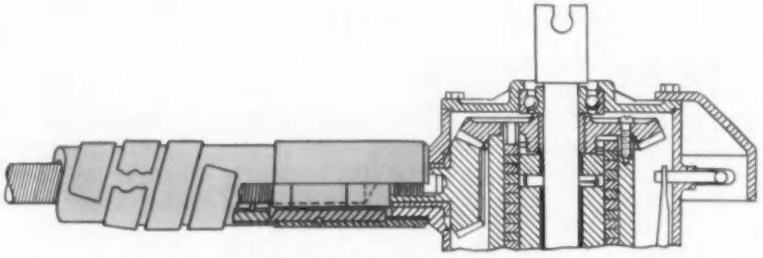
Ferrule and Screw Fitting Design



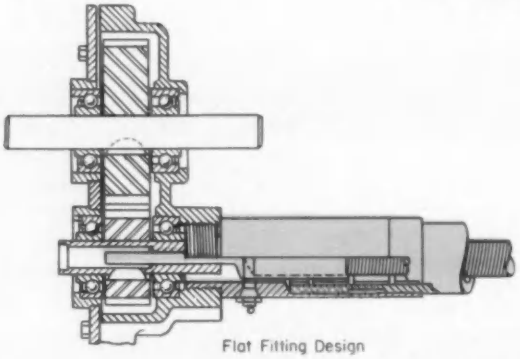
Design where Shaft End Bearings and Ferrule are Eliminated



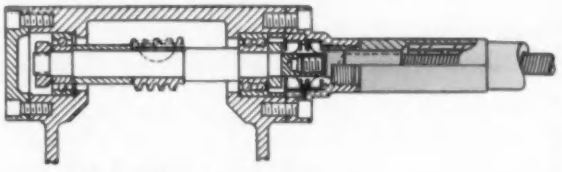
Design Using a Union Ferrule



Design Using a Swivel Ferrule



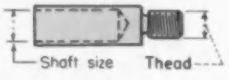
Flat Fitting Design



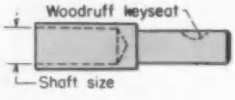
Design Using a Screw Fitting

Typical Core Fittings and Casing Ferrules

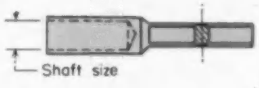
CORE FITTINGS



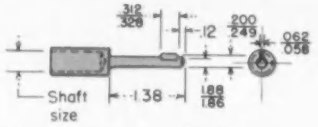
Recommended for one end and one direction of rotation only



Recommended for one or both ends. May rotate in either direction.

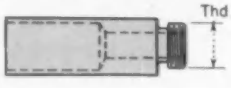


Recommended where there is relative motion between mating parts.

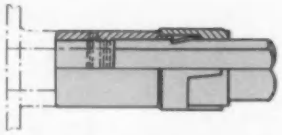


Recommended for one or both ends and rotation in either direction.

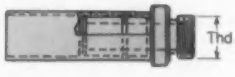
CASING FERRULES



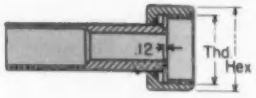
May be used at one end only when both mating parts are fixed. If one mating part is free to rotate may be used on both ends.



Recommended for use where frequent disassembly is desired.



Swivel unit for use where angular relationship of mating parts change during operation



Union type for use where mating parts on both ends are fixed

Types of Casings for Power Drive and Remote Control Applications

METALLIC

Kupfrian Mfg. Co.
Single Flat Wire Monocoil

Stow Mfg. Co.
Two Wire Casing

METALLIC CASINGS

SINGLE FLAT WIRE MONOCOIL CASING. Inexpensive type that can be used for power drive applications where flexing in operation is critical. Available in galvanized steel, brass, stainless steel and bronze.

TWO WIRE CASING made of two formed wires accurately wound together. It is low in cost and recommended for power drive and remote control applications not subjected to severe climatic conditions. Four wire type is similar, but wires are not as heavy. Extra winding results in a pitch that stiffens the casing transversely.

INTERLOCKED METAL ASBESTOS PACKED CASING. These are available in galvanized steel or phosphor bronze. Asbestos packing is placed in joints to make the casing grease tight. Recommended for remote control only in fixed installations.

LINED INTERLOCKED METAL CASING. Available in either galvanized steel or phosphor bronze with oil tempered spring steel interliner. This type is recommended for power drive shafts in fixed installations.

INTERLOCKED NON-MAGNETIC CASING WITH BRAIDED WIRE COVERING. Phosphor bronze casing is used and braid can be copper or aluminum wire.

S.S. White, Ind. Div.
Interlocked Casing

Stow Mfg. Co.
Lined interlocked

S.S. White, Ind. Div.
Interlocked Non-magnetic

COVERED CASINGS

S.S. White, Ind. Div.
Cotton Yarn Braiding

S.S. White, Ind. Div.
Rubber Covered

COVERED CASINGS

COTTON YARN BRAIDING AND WEAVING. Finished casings are impregnated with black shellac and hot burnished, giving moisture-resistance and a smooth, bright finish. Used for small flexible shaft machines.

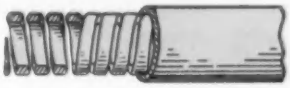
RUBBER COVERED FLAT SPRING STEEL, two or four wire casing. Covering is water tight and resistant to oil. It is also suitable for severe service. Recommended for general power drive applications where a tough, durable, yet flexible, casing is desired.

HEAVY DUTY RUBBER CASING having an additional wire braid for greater transverse stiffness and resistance to stretching under severe service. Units are also oil and water tight and have a high resistance to abrasion.

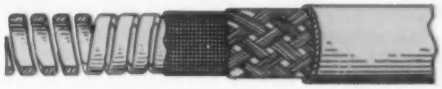
PLASTIC COVERED FLAT SPRING, two or four wire casing. Uneffected by oils, greases and gasoline and highly resistant to abrasion. Casings are recommended for remote control applications. Should not be exposed to high temperatures.

HEAVY DUTY PLASTIC COVER made with two or four or flat spring steel liner. Successive layers of cotton tape, wire braid and polyvinyl are used. Unaffected by oils, greases and gasoline. Should not be exposed to high temperatures.

Stow Mfg. Co.
Heavy Duty Rubber



S.S. White, Ind. Div.
Plastic Covered



S.S. White, Ind. Div.
Heavy Duty Plastic

GEARING. To increase or decrease the speed of the operating device or tool, gearing can be used. The gearing should be located so that the flexible shaft operates at the highest speed. As noted previously high speed operation results in a lower torque on the shaft. The lower the torque, the smaller the shaft which means a lower weight and a lower overall cost. Fig. 6 illustrates gearing placement for increasing or decreasing tool speed.

CASING FUNCTION AND SELECTION

An uncased flexible shaft tends to buckle or helix as the applied load increases, thus restricting the available output torque. With short lengths–about 20 shaft diameters–the full rated load may usually be applied without difficulty. On longer lengths of uncased shafts, similar performance may be obtained by using brackets or supports. Generally, shafts are protected by a flexible casing.

Two factors affect casing selection: (1) operating conditions, such as climatic, flexing, abrasion, resistance to stretching and others; and (2) the cost.

The primary function of the casing is to guide the shaft. This permits smooth and true operation. One of the major concerns in any flexible shaft installation is the tendency of the shaft to loop. The casing provides rigidity to the installation and prevents helixing of the shaft. Where tranverse bending of the enclosed shaft is a problem, the heavier braided casings will control this problem. Finally, the casing protects the shaft from moisture, dust and injury and also retains shaft lubrication.

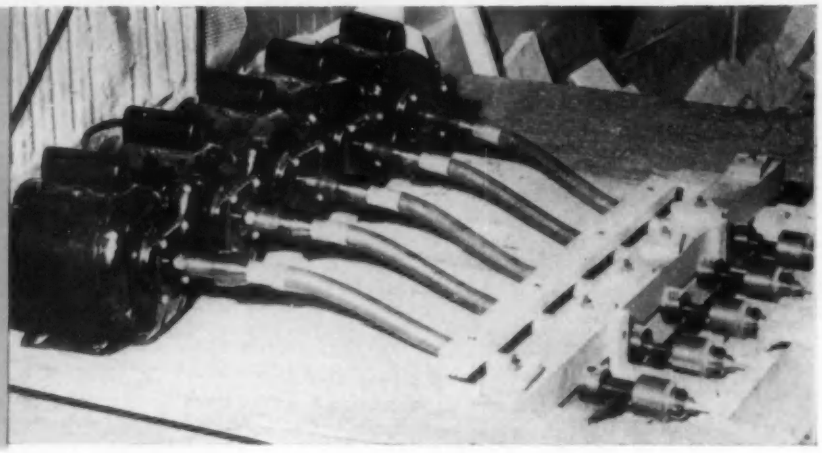


Fig. 8—Tool shafts arranged for multiple drilling. Arrangement of drills can be changed by clamping the headpieces in a different jig.

SELECTION OF FITTINGS

The terminal on a core is called a fitting; that on the casing is a ferrule. Core ends do not usually require an independent support, especially where the shaft is not so sharply bent that it places a heavy side thrust on the ends of the casings. In such instances, the casing may simply float on the shaft, with a slight space allowed at each end of the shaft, if the case elongates from bending. However, to provide adequate casing support, less drag on the core, better sealing of the lubricant and more shaft protection, the casing is mounted independently at each end by means of a ferrule.

Before end terminals can be selected, the following general rules should be remembered:

1. Since only the core of the shaft rotates, the core and casing must be connected independently of each other. The core end fittings are designed to engage with the rotating parts of the connected members, while the casing end ferrules are designed for rigid attachment to the rigid housing of the rotating parts.

2. The outside diameter of one of the core fittings must be smaller than the inside diameter of the casing and both casing ferrules in order to assemble the shaft.

3. If both of the connected members are fixed in position or are so large that neither can be easily turned, and if both casing ferrules are of the screw type, one of them must be a swivel type so that the unit can be assembled.

4. The core fitting should not extend into the casing beyond the back of the casing ferrule. This is to prevent wear of the fitting by rubbing against the casing when it is bent.

Fittings are attached to the core by soldering or swaging. Soldering is used where the quantities involved are small. Swaging requires the use of special dies but is more economical on a quantity production run. Ferrules are attached to casing by swaging, crimping or soldering. Again, soldering is used in small quantities on metal casing, while different methods of swaging or crimping are used in large quantities or on rubber casing.

When the design of either the driving or driven member cannot be changed to adopt a flexible shaft, complete units with built-in bearings can be supplied with couplings. The alternative—which is more economical in large quantities—is to design the connection components (driving and driven member) and the shaft end terminals to form an integral design connection. With integral design connections the shaft has less stiff length at each end than flexible shafts with built-in bearings which is desirable, particularly where short shafts with sharp bends are used.

Flexible Shaft Application Problems

1. A pump has a rating of 86 gal per min, operating at a speed of 400 rpm with a relief valve setting not to exceed 35 psi. This rating is equivalent to a brake horsepower of 2.85. If the operating radius is 25 in., what is the smallest size flexible shaft core that may be used?

$$\text{Torque} = \frac{\text{hp} \times 63{,}000}{\text{rpm}}$$

$$T = \frac{2.85 \times 63{,}000}{400}$$

T = 449 in-lb—the design torque

From Table 1 and a 25 in. radius of curvature, it can be seen that the 100 shaft No. 16 which has a rating of 520 in-lb, will be required. The fact that the speed of 400 rpm is lower than the rated speed does not effect the torque capacity of the shaft since these torque ratings are the maximum allowable.

2. A flexible shaft 52 in. long has a 45 deg bend. It is supported by clamps in such a way that 5 in. of the flexible shaft at each end are straight. The operation takes 1.5 hp at 1,800 rpm. Starting torque is estimated to be 150 per cent of the normal operating torque. What is the smallest size core that may be used for this application?

$$\text{Torque} = \frac{\text{hp} \times 63{,}000}{\text{rpm}}$$

$$T = \frac{1.5 \times 63{,}000}{1{,}800}$$

$$T = 52.5 \text{ in-lb}$$

Correction factor for starting torque is 150 per cent of normal torque.

1.50x52.5 in-lb = 78.7 in-lb design torque.

Since 10 in. of the 52 in. shaft is solid, there are only 42 in. left to make the 45 deg. bend. This would be $\frac{1}{8}$ the circumference of a circle. Therefore, $2\pi r/8 = 45$; $r = 57.4$ inches-radius of curvature. Refer to Table 1. Read downward in column "50 to straight" for a core having a rating of at least 78.7 in-lb. Although shaft No. 10 (0.387 dia) has a rating of 90 in-lb at 1,500 rpm, the rating at 1,800 rpm is 75 in-lb which is too low. The next size shaft No. 11 (0.500 dia) however, is good.

$$\frac{136 \times 1{,}150}{1{,}800} = 86.8 \text{ in-lb}$$

(rated torque at 1,800 rmp)

3. A flexible shaft is used to transmit power to a 30 in. dia circular saw. Blade torque is 25.8 ft-lb to cut at 2,230 fpm. A clutch mechanism presses a 2.5 in. dia roller which is directly connected to the flexible shaft against the saw blade at a radius of 14 in. In normal operation, the shaft would not be bent more than 20 in. radius. (A) Calculate the hp needed if the shaft is 92 per cent efficient, and (B) select the smallest flexible shaft core that will meet these requirements.

$$\text{rpm of saw} = \frac{\text{surface cutting speed}}{\text{circumference of saw}} = \frac{2230 \text{ ft/min}}{\frac{30\pi}{12} \text{ ft}}$$

$$\text{rpm of saw} = 284$$

$$\text{rpm of shaft} = \frac{284 \times 14}{1.25} = 3{,}180$$

Since the horsepower will remain constant between the saw and the clutch, torque on the clutch x 3,180 rpm = 25.8 ft-lbx12x284 = 27.8 in-lb. Correction factor for unsupported shaft is 1.6. Therefore–

$$27.8 \times 1.6 = 44.5 \text{ in-lbs}$$

$$\text{H.P.} = \frac{\text{torque} \times \text{rpm}}{63{,}000} = \frac{44.5 \times 3{,}180}{63{,}000}$$

$$= 2.25$$

Since the shaft is 92 per cent efficient, the engine brake hp $= \frac{2.25}{} = 2.44$. Therefore, a 2.5 hp. engine would be used.

$$\text{(b) Torque} = \frac{\text{hp} \times 63{,}000}{\text{rpm}} = \frac{2.44 \times 63{,}000}{3{,}180} = 48.4 \text{ in-lb}$$

Refer to Table I. Read downward in column 20 in. radius for a core having a rating greater than 48.4 in-lbs at 3,180 rpm. Core No. 13 (0.610 to 0.618 dia) has a rating of $\frac{176 \times 900}{3{,}180} = 49.8$ in-lb (at 3,180 rpm). Therefore core No. 13 is correct.

4. A flexible shaft is used to drive a 2 hp blower fan. Rpm of the power take-off is 550, while that required by the blower is 1,800 rpm. Flexible shaft is supported and has a minimum operating radius of 20 in. (A) What size shaft will be required if the gear box is put on the blower end of the flexible shaft? (B) On the power take-off end?

$$\text{(a) Torque} = \frac{\text{hp} \times 63{,}000}{\text{rpm}} = \frac{2 \times 63{,}000}{550}$$

$$= 229 \text{ in-lb}$$

Referring to Table 1 and looking down the column 20 in. radius, it is noted that No. 16 shaft (0.998 to 1.004 dia) is required.

$$\text{(b) Torque} = \frac{\text{hp} \times 63{,}000}{\text{rpm}} = \frac{2 \times 63{,}000}{1{,}800}$$

$$= 70 \text{ in-lb}$$

Again referring to Table 1 and looking down the column 20 in. radius it is noted that core No. 12 (0.505/0.511 dia) has a rating of

$$\frac{148 \text{ in-lb} \times 1{,}150}{1{,}800} = 94.5 \text{ in-lb (at 1,800 rpm)}$$

so core No. 12 is good

5. A flexible shaft is used to operate a non-rising stem gate valve by remote control. Shaft is 40 ft long, and it takes 1,500 in-lb of torque to open or close the valve. Total deflection of the shaft must not be over 100 deg. Select the flexible shaft to be used.

Deflection per foot = 100/40 = 2.5 deg/ft. Refer to the charts in Fig. 4.

The smallest shaft that will transmit 1,500 in-lb has a 1.300 dia. Checking the deflection per foot in the unwind direction on the graph for 1,500 in-lb however, shows that this shaft deflects 3 deg/ft which is more than that required. The next size shaft deflects only 1.5/deg/ft at 1,500 in-lb and so is satisfactory. Therefore the 1.613 dia core is correct.

6. A valve is controlled from a point 31 ft away. Connecting remote control shaft is supported by clamps and descends vertically from the vertical shaft of the handwheel to a point where it will turn and be layed horizontally in a straight line to a point directly over the valve and then descend vertically to the vertical shaft of the valve handwheel. Radius of the two bends in 24 in., and the horizontal distance between the valve and its control is 10 ft. Shaft is 75 per cent efficient. Assume a force of 100 lb on the rim of the handwheel. Handwheel on valve is 9 in. dia. (A) How large should the top handwheel be? (B) What size shaft should be used if the total torsional deflection must not be more than 120 deg.

(A) Torque = 100 lb $\times \frac{9 \text{ in. dia}}{2}$ = 450 in-lb. Since shaft is 75 per cent efficient the torque required to operate the shaft on deck is 450/0.75 = 600 in-lb.

Therefore a 12 in. dia handwheel should be used.

(B) Adding up the distances to get the total length

$$31 \times 10\left[8 - 2\frac{(2\pi r)}{4}\right] = 39.28 \text{ ft.}$$

$$\text{Deflection per foot} = \frac{120}{39.28} = 3.05 \text{ deg/ft.}$$

Looking at the graph in Fig. 4, the smallest shaft that will transmit 600 in-lb is the 1.000 dia shaft. At 600 in-lb the deflection per foot is 2.9 deg/ft which is within the limits. Therefore the 1.000 dia. shaft is correct.

Fundamental Types of

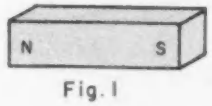


Fig. 1

Fig. 1—Simplest form of a permanent magnet is a bar exhibiting two poles which may be of any cross section.

Fig. 2

Fig. 2—U or C-shaped permanent magnets consist of a bar "bent" to bring both poles in the same plane.

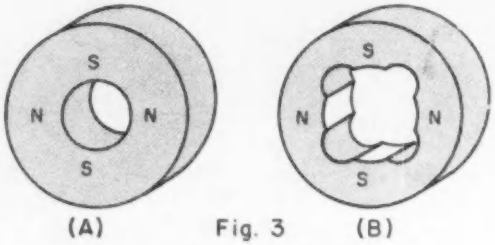


Fig. 3—A cylindrical magnet can be magnetized with as many poles as desired on the outside diameter as in (A) or the inner diameter as in (B) and can be made nonsalient (A) or salient (B).

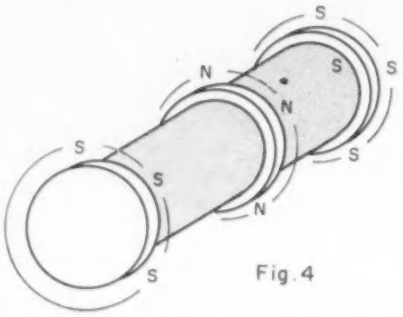
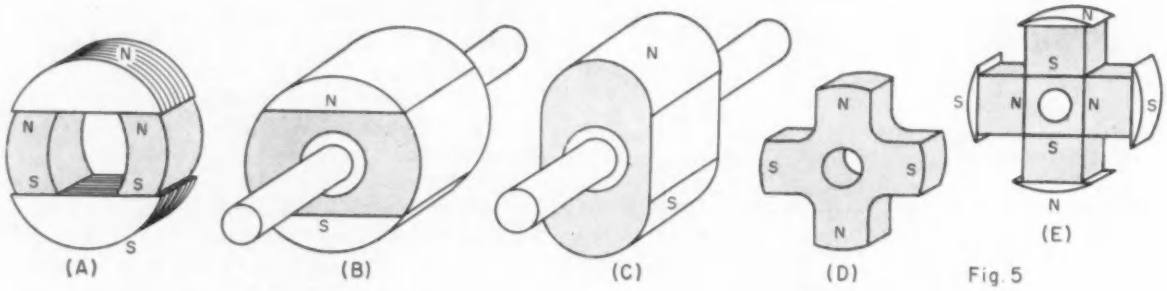


Fig. 4—Magnetic roll for handling material (separators) made up of 2-pole magnets and steel pole pieces which supply equal magnetic field on 360 degrees of the pole surface.

Fig. 5—Magnets for generators and other devices may be assembled from multiple magnets with laminated (A) or solid pole pieces (E), cast with inserts for pressing in shafts, nonsalient (B) or salient (C) or cast for assembly on shafts (D).



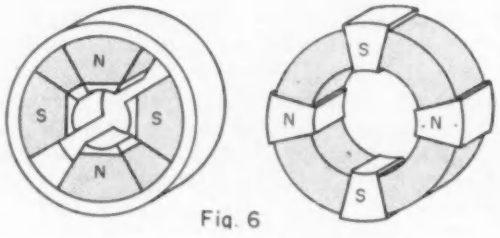
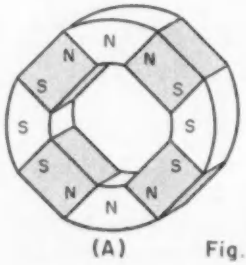
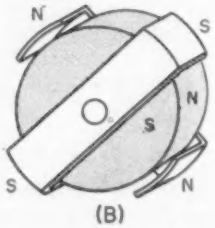


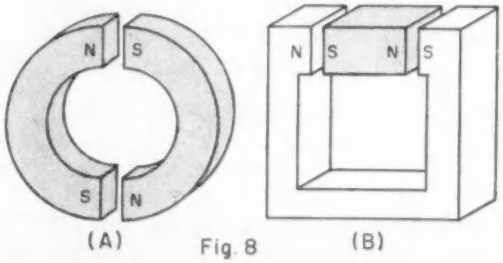
Fig. 6—Stator or internal pole assemblies using steel pole faces and magnets are made in various ways depending on mechanical, space, magnetic and physical characteristics required.

Fig. 7—Another 4-pole magnet using soft steel. Although only a 4-pole unit is shown, it is possible to incorporate as many poles as required (A) using bar magnets. In style (B) it is possible to obtain as many poles as desired using one 2-pole magnet.

Fig. 8—Double air-gap assemblies without steel poles (A) and with steel poles (B).







Permanent Magnets

Carboloy Department
General Electric Company

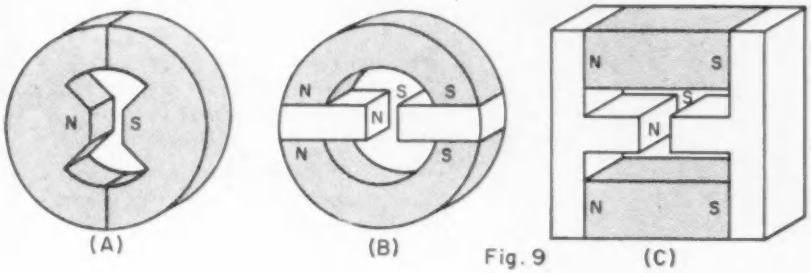


Fig. 9

Fig. 9—Fixed air-gap magnets made from a multiplicity of magnets without steel pole pieces (A) or with pole pieces (B) (C).

Fig. 10—Simple fixed air-gap magnets (A) without or (B), (C) with pole pieces

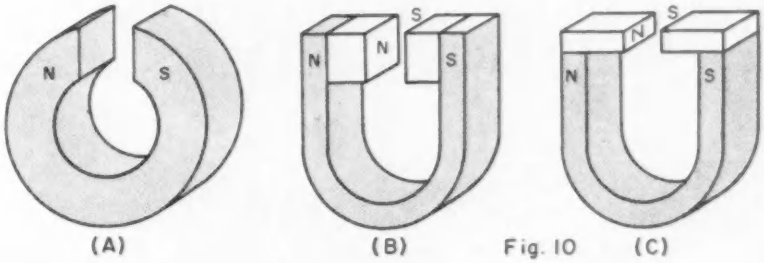


Fig. 10

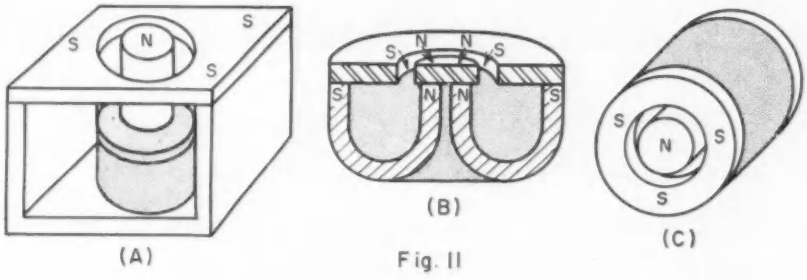


Fig. 11

Fig. 11—Annular air gaps are useful in instruments and loudspeakers. The magnets may be (A) plug (B) cylindrical or (C) ring depending upon application.

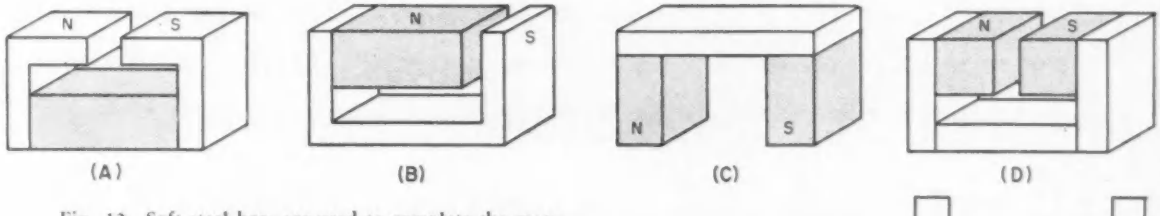


Fig. 12—Soft steel bars are used to complete the magnetic circuit, allowing maximum flux density through the air gap. Arrangement may use single magnets (A), (B) or double magnets (C) (D) (E) or single magnet with shunt (F).

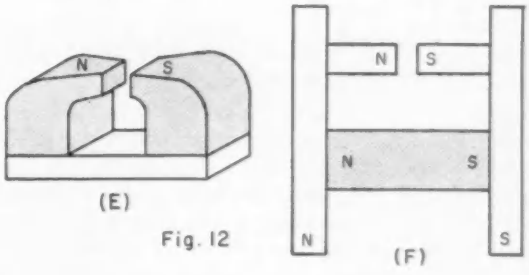


Fig. 12

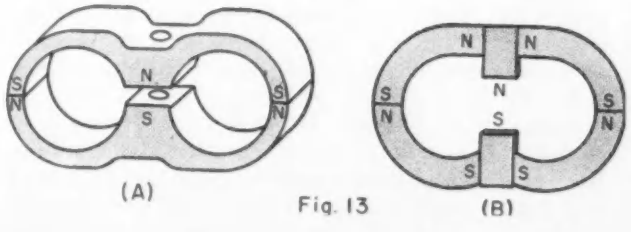


Fig. 13

Fig. 13—Special shaped magnets such as radar types—three pole E-style (A) and concentric gap bowl type (B).

Design Considerations When Using

Glass-to-metal Hermetically Sealed Terminals

Hermetically-sealed glass-to-metal electrical feed-through terminals consist of one or more metal pins fused into an inorganic insulation of glass, which in turn is fused to a metal mounting plate. The plate is attached to the sealed envelope by soft soldering or resistance welding.

These terminals have been used in increasing numbers for many electrical and electronic applications during the past few years, particularly in the refrigeration, relay, and transformer industries. They are adaptable to most requirements for the feed through of electrical current to components permanently sealed in a stabilized atmosphere.

The stout hermetic terminals now available, when properly designed into the equipment, can be handled with no great difficulty in production.

Improvements in strength and reliability of glass-to-metal hermetically sealed terminals have greatly increased their applicability. Often a real aid in miniaturization, they can provide mechanical support for components in addition to their primary function of electrical feed-through. In many instances, particularly in large scale production, use of these terminals in equipment design can result in cost savings over use of other terminal mechanisms. No production problems are generally encountered even when used in pressurized or evacuated enclosures.

ANDREW WYZENBEEK
Chief Engineer, The Fusite Corporation

HERMETIC GLASS-TO-METAL TERMINALS are supplied in two basic types: "singles" and "multiples." The former has only a single pin, while the latter may have any number of pins fused into an integral unit. Fig. 1 shows typical examples of both types.

The single terminals are now available in many sizes, with popular "standard" sizes ranging from those requiring $\frac{1}{8}$ in. dia mounting holes to those requiring $\frac{1}{2}$ in. holes. In general, electrical rating is directly proportional to size. The most common varieties of single terminals currently in demand are: (1) "Feed throughs" with flanged-eyelet bodies designed for soft solder assembly; (2) "feed throughs" with threaded bodies for difficult-to-solder and high-vibration applications; and (3) "stand-offs" for high-performance junction points.

The multiple terminals have been applied as subminiature headers for transistors, sturdy high-pressure terminals for hermetic refrigerator compressors, and as miniature and octal-type headers for plug-in applications. Electrical rating is proportional to size, as for the single terminals. Various sizes and flange configurations are available in each variety for adaptation into existing component designs and available cans. A wide selection of pin designs is offered as standard for both the single and multiple terminals, as shown in Fig. 2. Basically, the pins may be divided into two catagories: solid pin, and hollow

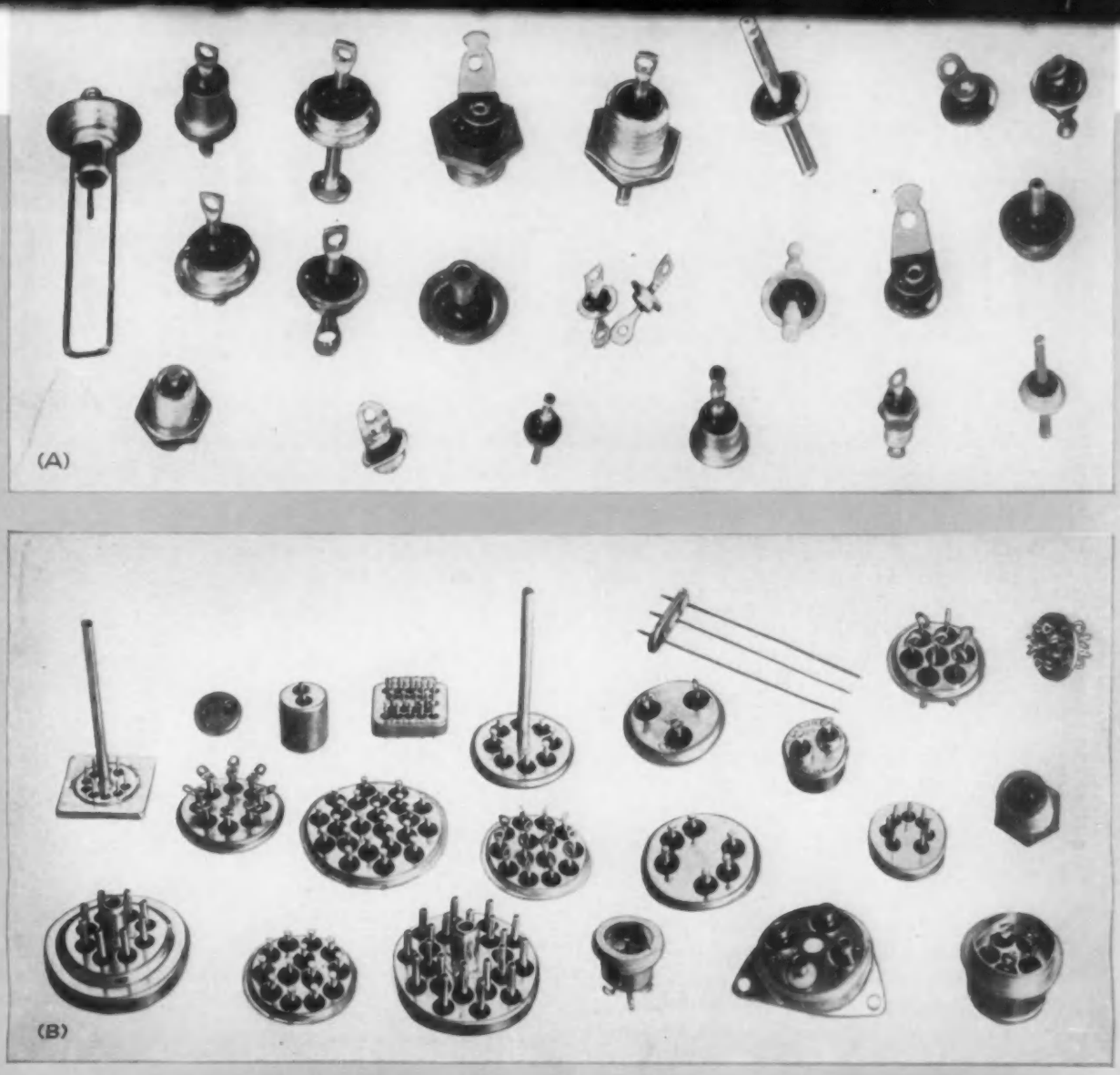


Fig. 1—Typical glass-to-metal hermetic terminals with various styles of pin heads. Single terminals (A) are available in many sizes as "standard", suitable for mounting in holes from ¼ in. to ½ in. dia. Pins may be solid or hollow, and flanges may be selected for most suitable attachment to the equipment housing. Multiple terminals (B) can also be had in a wide variety of pin and flange styles; pins may be selected which offer most convenience in connecting lead wires, either by soldering or welding.

tube. The solid pins are generally suitable for solder attachment of lead wires, both with and without the frequently desired auxiliary mechanical joints, but resistance-welded and mechanical-clip connections are also provided for. Hollow-tube pins permit high-conductivity or special-alloy leads to be fed directly through the terminal after which the leads may be sweated in place.

Design Considerations

There are a number of design considerations in selecting the right terminal or header for a given application. "Standard" terminals are stocked and can often be selected directly from the manufacturer's catalog according to size and performance. Even in such cases, it is advisable to supply the manufacturer with as much information as possible so that appropriate selection may be confirmed or a more suitable alternate recommended. Where special design considerations require that a special header be custom-built for the job, it is important to consult the terminal manufacturer early in the design stage of the component and its enclosure. The following design considerations are those which are most commonly involved, although the order of importance may vary with the application.

SPACE LIMITATIONS. The trend toward component miniaturization imposes important space limitations. Because of limited chassis space, electrical components must often be mounted with their long axis perpendicular to the chassis and wedged closely together. Terminals must then

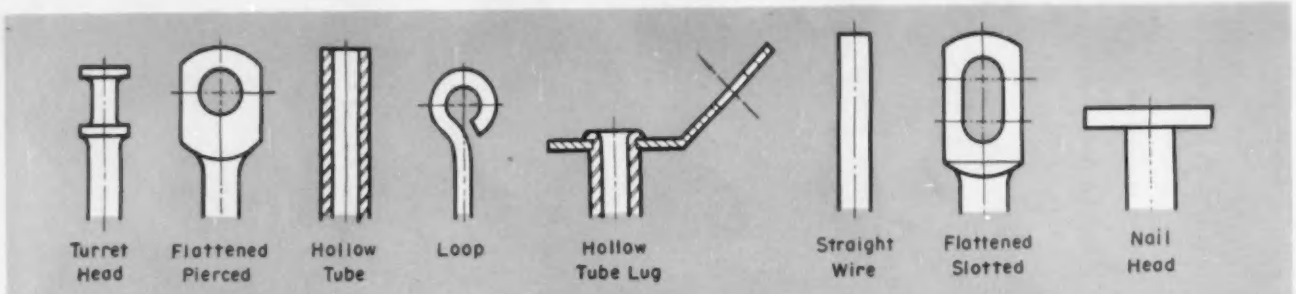


Fig. 2—Typical internal and external pin-head styles. One style may be selected

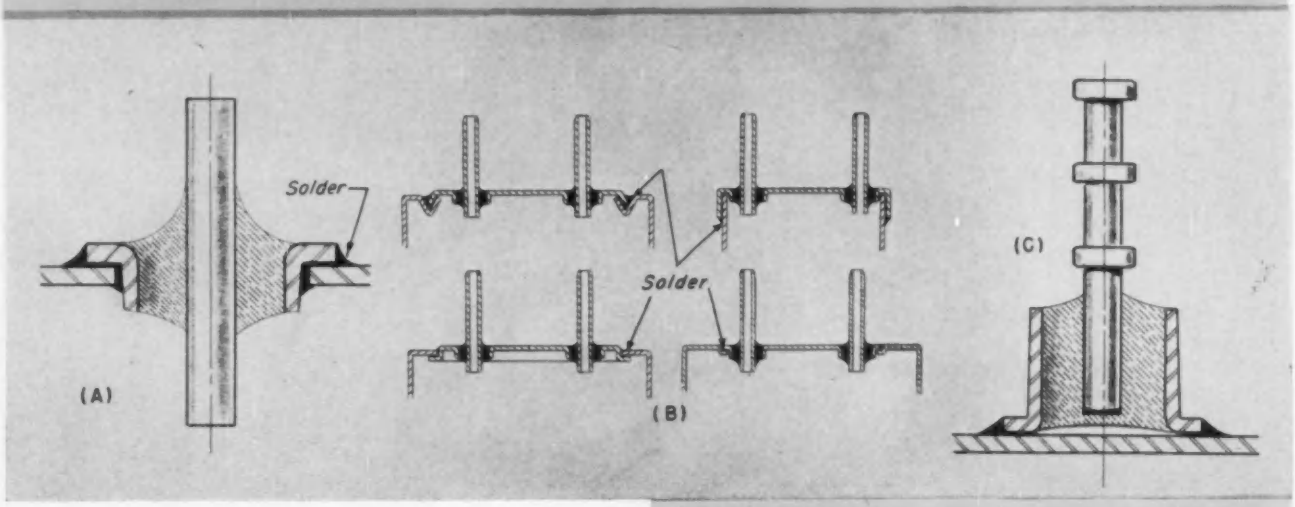
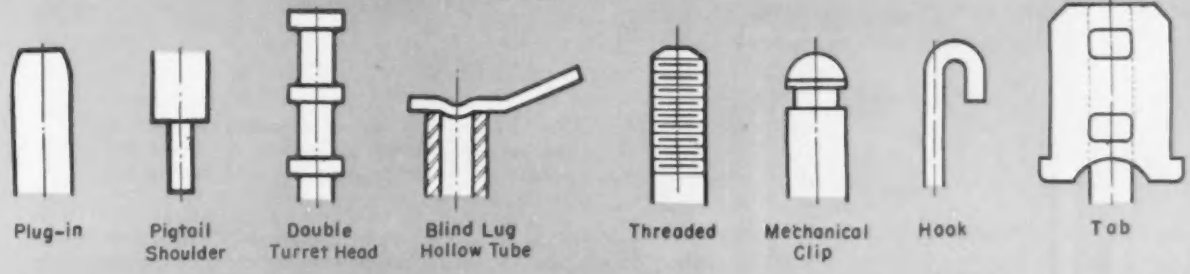


Fig. 3—Soldering suggestions for typical single and multiple hermetic terminals. No special precautions need be taken to protect the terminals. (A) Single-terminal solder assembly. A complete seal around the flange can be obtained as shown. (B) Solder assembly of multiple terminals with various flange styles. The few flange types shown give indicaton of the many possibilities of design for solder sealing. (C) Solder-mounting of a stand-off for a junction point. Welding could also be used.

be placed on either the top or bottom of the enclosure where minimum areas are available. Terminals on cylindrical enclosures must necessarily be placed on the ends which have little area for the purpose. Reduction in component size has necessitated the use of smaller hermetic terminals; for example, the miniature-relay multiple terminals and the minute transistor headers. Not only is there the problem of reduced space in which to fit the same number of feed-through leads; there must frequently be almost no sacrifice of other design considerations. The available space for the terminal or header may limit both the internal and external pin extensions. Fortunately, higher quality glass-to-steel terminals are now available which permit the wire attachment joints to be closer to the glass than was formerly possible. It is important to leave enough space in component design, however, for convenient assembly in production.

ASSEMBLY. Once the general shape of the hermetic enclosure has been decided upon, the assembly (integration of the terminal into the enclosure) should be considered. If a drawn can is used for enclosure, the number of seams to be solder sealed is greatly reduced. The header can be placed in either the closed end of the can or in the lid; the can-lid mounting is preferred. This permits various flange treatments, particularly with the multiple headers, and a choice in type of solder seam best suited to the application. The header may be attached to the inside of the enclosure or lid, which is often best for pressurized enclosures; or the header may be attached to the outside, which may offer some assembly advantages. Most headers are round; thus, tools required to adapt the enclosure for insertion of the header are relatively simple and inexpensive. Cylindrical enclosures and circular headers make a natural combination; and standard headers in a variety of diameters are available, which mate with stock enclosures. Whenever possible for the header to be the entire can cover, possible assembly economies are obvious. Reasonably large production quantities are usually required, however, to warrant the expense of the special tooling involved; particularly for an oval or rectangular one-piece combination lid and header.

Soft soldering is the usual method for joining terminals to enclosures. This can be done with irons, torches, and ovens or by infrared, induction, and hot oil immersion, depending on component design. Where several solder seals are required in succession, solders with different melt-



for internal head, another for the external head.

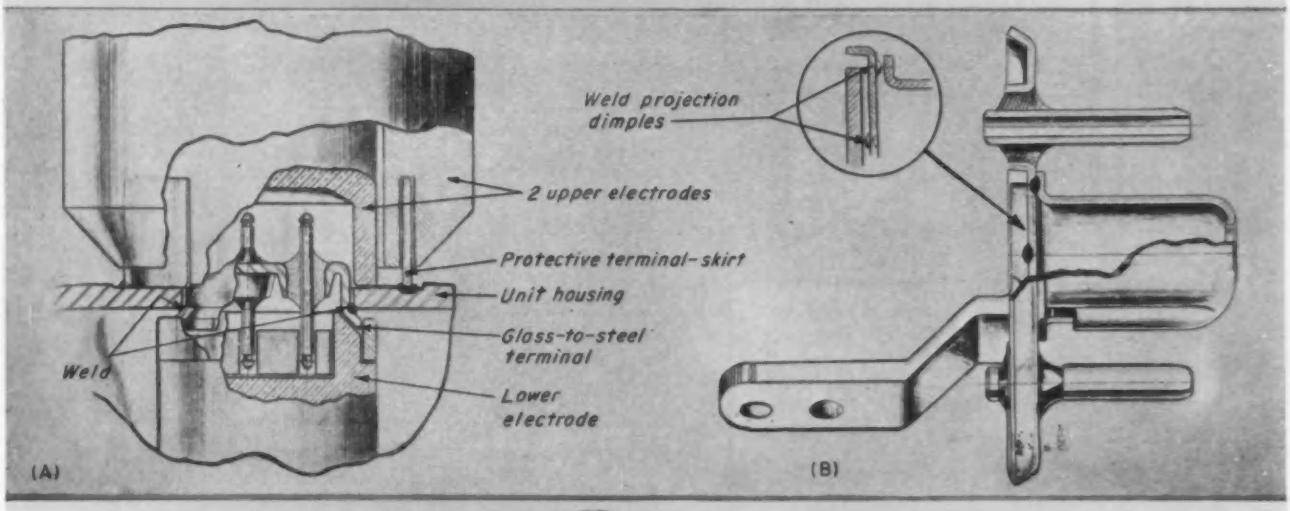


Fig. 4—Weldments of (A) a glass-to-metal terminal on a refrigerator compressor (Fig. 9 shows the actual operation); (B) of component bracket attached to an octal-type terminal.

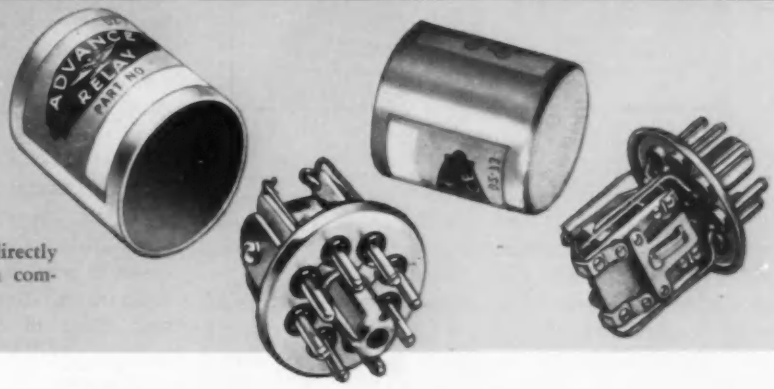


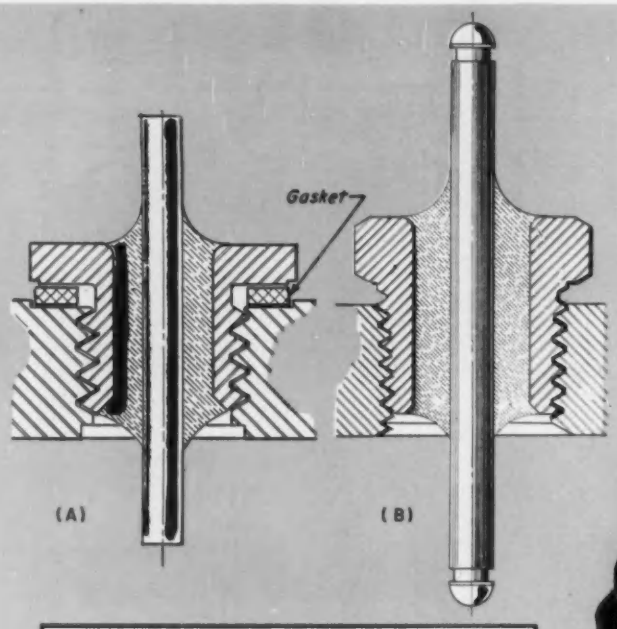
Fig. 5—Relay with components mounted directly on glass-to-metal terminal. This results in compact design and short electrical leads.

ting points can be used. Typical solder-assembly suggestions are shown in Fig. 3.

Resistance welding may be used in certain specialized applications where both terminal and enclosure have been designed for it, as in Fig. 4. Annular projection welds are most suitable; and although some applications require only the terminal panel to be joined to the unit, it is often necessary to join component mounting devices to the terminal panel as well, as at (B) in Fig. 4. Relay manufacturers often use welding to attach component-mounting structures directly to the under side of the finished glass-to-metal terminal panel, as in Fig. 5. The weld provides a solid joint without requiring a hole through the hermetic enclosure.

PIN SELECTION. Some factors which affect selection of pin type, including end treatment and fabrication, are: (1) Connection of wires internally, (2) type of mechanical joint, (3) required load current, (4) number of leads to be connected to each pin, (5) permissible pin extensions, (6) required pin strength and (7) relative cost of various pin styles.

Headers with hollow-tube pins are often preferred. Advantages are: (1) The inside extension of the tube can be held to a minimum, since the lead wire is fed directly through the tube with no interior joint being made; (2) the feed-through of a high-conductivity lead wire may permit higher currents to be carried or may reduce voltage drop in critical circuits; (3) thermocouples and thermocouple lead wires may also be fed through without interruption and without the introduction of dissimilar material joints; (4) solder lugs may be provided on the external portion of the tube as an aid in puddling the solder, in capping off of the tube, to provide for multiple connections at a reasonably



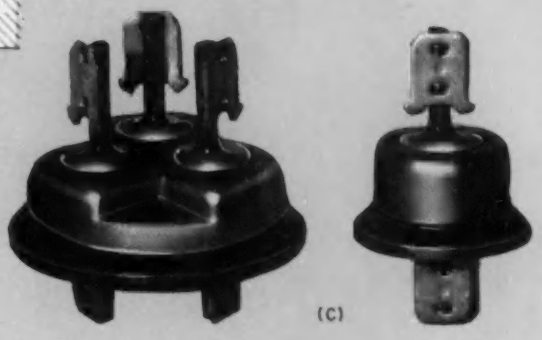


Fig. 6—Terminal designs especially adapted to pressure and vacuum applications. (A) Cross-sectional view of terminal with threaded bushing and gasket to assure tight seal. (B) Pipe plug cross-sectional view for pressure or vacuum applications, showing typical mounting. (C) "Reefers" used in refrigeration work where pressure or vacuum conditions exist.

Table I—Approximate Current Rating for Glass-to-Metal Feed Through Pins

Pin Dia., in.	Max. Current, amp
0.040	5½
0.050	7½
0.062	10
0.093	15

safe distance from the cap-off point.

If solid pins are used, interior connections to the header are unavoidable. Such connections should not only make good electrical contact but also be mechanically strong, so that subsequent external connections will not cause the internal ones to loosen. The turret-head, flattened pierced, and loop-pin styles each provide an excellent mechanical and electrical joint when used with soft solder. The straight-wire and pigtail-shoulder styles are also used for internal solder connections, especially where the external connection is other than a solder joint (plug-in). For resistance welding, the straight-wire and the nail-head pin styles are frequently used for internal connections. Cross wire welding of a solid lead to a short straight-wire pin makes an excellent and space-saving connection; and the nail-head pins are ideally suited for weld attachment of foil. Elements of relays and switches are often attached to the terminal pins. Thus, structural use may be made of the rigidity and excellent insulation of the glass, and may permit fewer parts in the design of the component. The mechanical-clip and tab-type pins find use with friction connectors which lock securely in place in the groove provided.

External pin treatment may be the same as internal; or a combination pin may be used with the internal and external treatments selected which best suit the connection involved. For use with plug-in components, the chamfered plug-in-type external pin treatment is available in combination with most types of internal connection. Custom-built special-purpose pins can be supplied at slightly greater cost when relatively large quantities are involved.

CURRENT RATING. The ferrous-metal terminals used in glass-to-metal hermetic seals have much lower conductivity than copper. This fact must be considered whenever appreciable current must be carried by the terminal. Pin diameter needed to carry the load often affects the minimum over-all dimension of the header. The maximum current rating of a given terminal depends upon several factors: (1) The method of lead-wire attachment both internal and external; (2) the heat dissipation means, such as size of lead wires and potting or filling compounds employed; and (3) the permissible temperature rise. Table I shows approximate maximum current ratings for hermetic terminals and may be used as a rough guide.

FLASH-OVER VOLTAGE. Voltage ratings are affected somewhat by operating conditions. At sea level, the flash-over voltage of a high-density vitreous insulator is primarily a function of the quality of the insulating surface, length of surface, and moisture film. The necessary insulation length to meet the required flash-over voltage will also normally affect minimum over-all dimensions of the header. For airborne equipment, the sea level flash-over ratings must be down-rated in accordance with the maximum altitude to be encountered. For instance, at 50,000 ft a safety factor of 3 or 4 may be required. Most glass-to-metal hermetic terminals are rated at 1,000, 1,250, 1,500, 2,000, 2,500 or 3,000 volts ac rms.

INSULATION RESISTANCE. At room temperature the insulation resistance of a glass-to-metal hermetic terminal is primarily a function of its surface resistivity and varies inversely with the relative humidity, the extent of variation depending on quality of the glass surface. The World War II insulation-resistance requirement of 10,000 megohms at room temperatures has long been used for an all-purpose industry-wide minimum test specification; however, current military requirements for increased insulation resistance at elevated temperatures has changed this concept. Headers are now available to meet Mil-R-5757B Class A, B, & C. Insulation resistance must be at least 50,000 megohms at 85, 125, and 200 C, respectively.

PRESSURE AND VACUUM. Most hermetic terminals for electronic applications are permanently leak free at a pressure of 1 atmosphere, and many will stand greater pressures. However, "pressure-seal" applications call for special consideration. High pressure performance can frequently be designed into the terminal; for instance, the multiple terminal for hermetically sealed refrigerator compressors withstands 350 lb gas pressure and 2000 lb hydrostatic pressure after the shock of resistance-welding assembly. Straight and taper-threaded bushing terminals are available which meet explosion-proof requirements of Underwriters' Laboratories. Terminals of this type can be used at pressures of 10,000 lb. per sq in. and greater.

The use of hermetic terminals for various vacuum processing operations, scientific instruments and gauges, and for airborne components operating above 80,000 ft, has resulted in the availability of terminals which remain leak free at very high vacuums. Also, many relay and switch manufacturers use a high vacuum to accelerate the degassing of materials which are likely to cause rapid contact-point failure through the emission of contaminating volatiles. This is accomplished by evacuating the assembly through an exhaust tube to below one-tenth of a micron; and after holding the vacuum at this point for a short time, back-filling with dry air or inert gas at atmospheric pressure or greater. Before back-filling and while the vacuum is being held, the effectiveness of the envelope, including the hermetic terminal, can be checked with mass-spectrometer leak detectors.

Some pressure and vacuum terminal designs are shown in Fig. 6.

Typical Applications

Two recent design applications show how hermetic terminals can serve as integral structural components, as well as for electrical feed through. One interesting application is the redesign of a miniature single-pole, double-throw snap-action switch. Moisture, dirt, and atmospheric changes affected reliability of the original switch for some applications. It was important that the action remain constant under adverse conditions, particularly in aircraft, and in the operation of machine tools. A hermetically-sealed switch solved the problem.

Since it was required that the new switch be completely interchangeable with the older one, physical limits imposed were severe. The relation of exterior actuating mechanism to the mounting holes could not be changed. These outside limits affected the available interior space where the

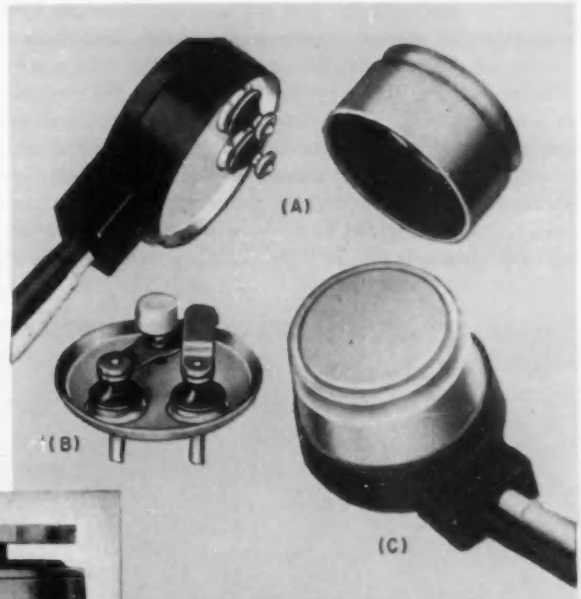


Fig. 8—Bimetallic automatic defrost switch for refrigerator, showing (A) terminal before attachment of switch elements, (B) after assembly, and (C) the completely enclosed assembly protected against dirt and moisture.

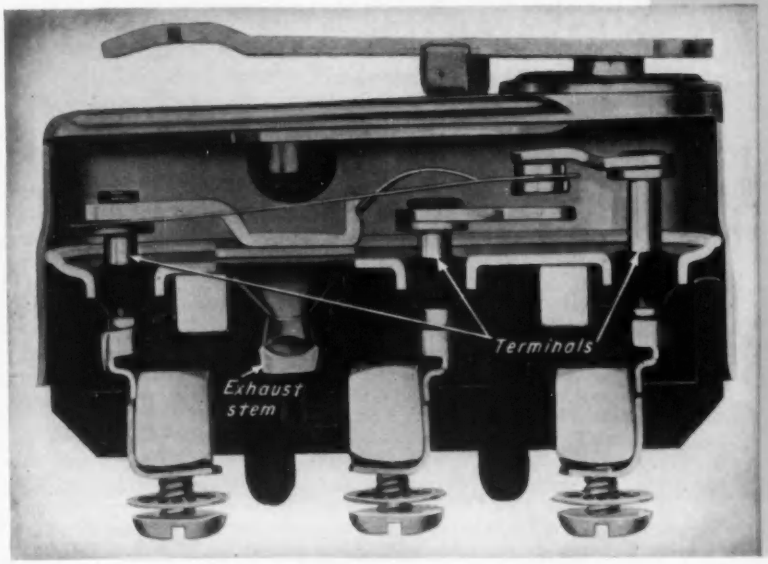


Fig. 7—Miniature hermetically-sealed snap switch using terminals as the structural supports. Evacuation of the contact area and the insertion of inert gas prolong contact life and insure normal operation in moist and dusty atmospheres.

mechanism was to be sealed. The final design is shown in Fig. 7. It is less than 2 in. long and ¾ in. wide. In addition to the three terminals, an exhaust stem was incorporated to allow evacuation of air and introduction of inert gas. The center lines of the three pins which vary in length from ⅜ in. to ½ in. were held to plus or minus 0.005 in. Under high heat the glass was fused to the pins and frame, resulting in an intimate, permanent bond. The switch manufacturer then fastened the entire switch mechanism to these pins by welding or upsetting. The frame was soldered to a steel enclosure; and outside the enclosure a phenolic base with exterior screw type terminals was attached.

Another and somewhat similar application is that of an automatic defrost switch which had to be enclosed within a small, circular metal container, as shown in Fig. 8. Again, the small interior dimensions made it necessary to keep the mechanism as simple as possible. This temperature sensitive bimetallic snap switch, when placed in the frosty region of a refrigerator evaporator, controls the defrosting mechanism. Sealing against moisture and dirt was necessary to insure continuous operation, but varying atmospheric pressure was not a factor in this case. Gaseous materials had to be eliminated to extend terminal point life, so hermetically-sealed electrical feed-through terminals were employed. In the final design the terminals support the switch mechanically but are also used for electrical feed through.

Cost has been an important factor to the refrigeration industry in the selection of glass-to-steel hermetic terminals for some applications. Savings as high as fifty cents per unit have resulted where used in refrigerator compressors—accomplished by cutting assembly costs. The present terminals used are assembled by projection welding in one swift operation, Fig. 9. There were early objections to the hermetic terminals on the basis that they were too delicate to withstand the manufacturing process. Some of the first post-war terminals required water-spray cooling while being resistance welded into the dome of the compressor. Later design refinement resulted in the necessary strength to withstand the roughest of welding operations. A cost saver for this type of assembly is a recently developed two-in-one welding operation. Using two concentric rams operating at slightly different levels, it is possible to weld the terminal flange into the compressor housing and a protective skirt around the terminal, all in a single operation. Also, practically all refrigeration manufacturers are using the same basic type of terminal, resulting in a considerable saving to these companies through the economies of volume manufacture. All fractional-horsepower compressors require three feed-through leads—one for the common connection, one for the main winding, and one for the starting winding. These three leads have been combined into a single-cluster multiple-terminal panel.

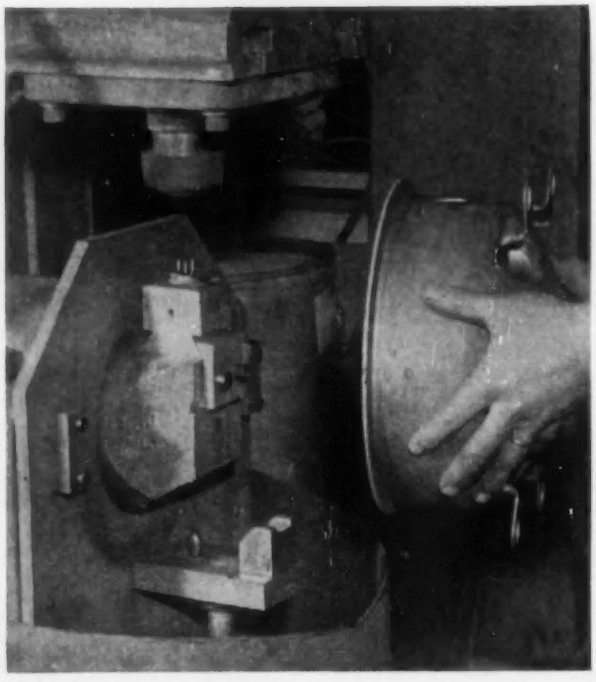


Fig. 9—Projection welding of hermetic terminal to refrigerator compressor housing. This is done in one simple operation.

A 45 deg flange at the base of the terminal plate, permits use of a straight punched hole of 1⅛ in. dia in the dome of the compressor. The surface opposite where the terminal is welded must be flat to provide proper conductivity between the steel and upper electrode during welding. The inside corner of the punched hole should be sharp with the die burr left in place. This sharp corner serves as a projection for making the resistance-welded joint and is fused into the 45 deg terminal flange.

Further illustrating the simplicity of the cluster design, the electrodes are of sufficient length so that all specifications of the Underwriters Laboratories through air and over glass are met when a mechanical clip is attached. The three electrodes may have grooves at each end, which serve to lock the clips onto the electrode so that vibration will not jar them loose. The clips also provide a satisfactory method for quickly attaching motor lead wires to the terminals. Three of these same clips, in a polarized phenolic socket attached to a wiring harness, may provide external connection for quick and inexpensive assembly. This also eliminates possibility of error in attaching wires during field service. These hermetically-sealed terminals are now used in compressors up to ¼ horsepower, operating on 115 and 230 volts. They will be used at higher ratings when more positive connections are developed to prevent excessive heat rise at the seal. By using "tab" type pins, which accept the solderless connector clips, Underwriters' approval has been obtained for use on compressors up to and including ¾ horsepower at 115 volts and 1 horsepower at 230 volts.

In *Product Engineering* for June 1954, page 178, R. V. Clark, chief engineer of Lundey Associates, gave selection data for various types of hermetic terminals, including the glass-to-metal variety. The latter have lower "leak rate" than the gasket, solder seal, and molded plastic types and compare favorable in temperature range, shock resistance, high-frequency usage, and insulation resistance versus temperature. For high-voltage use they tend to be rather costly and subject to surface tracking under polarized-voltage operating conditions. For such applications, where space limitations are not of concern, other types should be considered.

In an article in the January, 1950, issue of *Product Engineering*, page 129, entitled "Glass-to-Metal Seals", Prof. Joseph A. Pask of the University of California, discussed factors in obtaining good glass-to-metal seals. Subjects covered included the criteria for good seals, physical and chemical considerations in matching glass to metal, sealing procedures, and types of seals.

Engineering Economics

The "dollar" yardstick of success has been applied less to the engineering function than to other corporate departments. This practice is an outgrowth of World War II, when industrial problems could be solved only by an all-out technical effort. But, with the return to a competitive economy, industry has found it more and more necessary to evaluate technical effort in terms of dollar return for dollars spent.

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Chief Engineer, Bennett Pump Division,
John Wood Company

THERE IS A WIDE DIFFERENCE of opinion on ways and methods of evaluating an engineering function. To a large extent, this situation exists because of the unavailability of a fund of historical data upon which to base the level of expenditures for engineering and research. Yet, decisions must be made as to the amount of money to be spent and how it is to be allocated. Once these matters are settled, a continuing analysis must be made of the results obtained from these expenditures.

BASIC REQUIREMENTS IN ENGINEERING BUDGETS

The practical approach to this problem of engineering economics is through a definition of the policies and objectives of the company, and the preparation of a budget which will accomplish these objectives. Typically, there are two basic requirements in the study of an engineering budget. These are determination of the total amount of money to be spent for the technical effort, and formulation of the pattern in which the budget will be allocated among the four main engineering functions; namely, Research, New Product Development, Product Improvement, and General Services and Supervision.

In determining the amount of money to be budgeted for the technical function, one of the more important factors to be considered by management is the amount of money spent by competitive or similar industries on research and engineering effort. Table I lists the results of a study of such expenditures in 191 leading industrial companies, according to classifications established by the Bureau of Labor Statistics. The expenditures in a particular company may be greater or less than these average values, depending upon such factors as the technical objectives of the company, type of products manufactured, and its ability to finance sizeable sums for research and engineering. The average increase of spending for 1952 over 1951, as shown in Table I, is approximately 13 per cent for all classifications. This is indicative of a trend that most companies are recognizing the importance of increasing their technical budget as the national economy becomes more competitive. And as this trend continues, it is evident that more and more attention will be concentrated on an accurate evaluation of the benefits received from these expenditures.

It is in the small and medium-sized technical organizations where closer attention should be given to the details of the technical budget and an evaluation made of the resulting engineering effort. The larger organizations generally maintain elaborate budgets, accounting and evaluation procedures, but in larger companies, especially those going through rapid large-scale expansions, there is the danger of expanding procedures beyond the point of diminishing returns, thus defeating the economic purpose of the expansion and tending to stifle technical achievement and freedom.

In determining the amount of money to be budgeted, those companies which have permitted their engineering departments to "just grow" are usually in a position to make some sort of financial analysis of engineering and research expenditures over a past period. Then, by studying the amounts of money spent by competitive or similar industries for a historical background, they can establish a tentative pattern for their own engineering and research expenditures.

Though the problem is more difficult in any newly developed engineering organization, a reasonable tentative

solution can usually be reached by the same steps. This information, together with the recommendations and tentative budget figures prepared by the engineering department will at least suffice as a basis for determining the total engineering budget.

The distribution of company-financed research work among the basic engineering functions, as determined by the survey of 191 typical companies referred to in Table I, shows half is devoted to product improvement, 42 per cent to new products and 8 per cent to basic research. These figures being averages, it can be seen there are some instances where more than half the work and expense goes into the technical budget on product improvement, because it is here that the quickest and most spectacular returns can be realized. This is particularly true of those companies that have allowed their product improvement and cost reduction programs to lag, as a reflection of the seller's market which prevailed from the end of World War II until 1953-1954. However, with the swing to a buyer's market, the company that concentrates on product improvement and lets its new product development slide may attain an enviable position currently, but is continually risking being put out of business in the future by competitive developments with which it has not kept pace. It is only by proper attention to both product development and product improvement that a company can maintain its competitive position today and also safeguard its future position.

Table I—Median Figures for 1952 Research Expenditures in 191 Leading Companies*

	Per cent of 4,800 Respondents Supporting Research	Per cent Research to Sales	Per cent Increase in Spending over 1951	Dollars Spent per Research Worker	Per cent Profes'l to All Research Personnel
ALL FIRMS	44	1.3	13	8,400	46
By Industry					
Food and Kindred Products	31	0.3	8	8,300	46
Textile and Apparel	34	0.7	7	8,200	39
Furniture	27	0.5	9	6,500	19
Paper, Lumber, and Wood Products	28	0.7	15	7,100	49
Industrial Chemicals	74	2.9	15	9,400	45
Drugs	59	4.9	12	9,600	46
Paints	72	1.7	8	6,800	52
Miscellaneous Chemicals	69	2.4	9	7,700	39
Petroleum and Coal Products	40	0.7	14	9,000	43
Rubber	53	0.9	21	8,500	66
Stone, Clay, and Glass	42	1.3 (est.)	14	7,700	37
Primary Metal	43	0.9	11	8,500	40
Fabricated Metal	40	0.7	10	9,600	53
Machinery except Electrical	61	1.4	12	7,300	39
Electrical Machinery	71	2.7	17	8,200	44
Transportation Equipment	51	1.4	9	9,700	36
Laboratory Instruments	87	3.0	40	7,300	37
Mechanical Instruments	69	2.0	11	8,900	52
Other Professional, Scientific, and Controlling Instruments	79	2.0	14	10,000	50
By Size of Company					
Less than 500 Employees	32	3.4	10	8,200	59
500– 2,000 Employees	80	2.0	16	8,100	49
2,000– 5,000 Employees	94	1.4	12	8,000	45
5,000– 7,000 Employees	96	1.2	12	8,200	50
7,000–10,000 Employees	97	1.5	13	8,500	46
10,000 Employees or More	99	0.8	14	8,700	41

* Dearborn, DeWitt C., Knesek, Rose W., Anthony, Robert N.: "Spending for Industrial Research 1951-1952", Division of Research—Harvard Business School, p. viii.

Usually, research will ultimately lead to both new product development and product improvement. However, the benefits to be derived from basic research, even that which is directed along definite possible applications to the company's product lines, are usually most difficult to evaluate. In many of the smaller organizations, it is feasible to handle the research function by contract with established organizations such as universities, foundations and the like. This will, of course depend upon company policy, past practice, facilities, and state of the art. But whether research is done within the organization or financed externally, it should be realistically evaluated along with the other functions of the engineering department.

DIVIDING THE ENGINEERING BUDGET

Great importance should be attached to segregating technical expenditures into the amounts chargeable to each of the four basic functions mentioned above. In describing a comparatively simple procedure for making this analysis in companies having a small or medium-sized technical organization, definitions of the basic functions should first be stated.

(1) *Research.* Basic and technological study, rather than sales or market analysis, from which the company does not expect immediate application to its development program.

(2) *New Product Development.* Completely new lines of products or major modifications of existing products which will result in a new model or type of product considerably different from that in production.

(3) *Product Improvement.* Those projects which apply to the existing lines in production and fulfill one or more of the following functions:

(a) Improvement in performance or quality of existing products.

(b) Cost reduction investigations and changes.

(c) Minor design changes for the benefit of modernization and appearance.

(d) Addition of models which will increase market coverage, yet will not call for extensive research and development.

(e) All engineering changes and associated investigations relating to existing products.

(f) Investigation of service complaints and projects designed to correct these complaints.

(g) Improving production methods.

(h) Material substitutions, simplification and/or new types of construction.

(4) *General Services and Supervision.* Engineering time and expenditures required for preliminary technical reports, supervision and administration of the engineering department. Also included are general services such as secretarial, personnel, making and distribution of prints, bills of material, and other administrative functions. These items are not usually classified as projects, but are carried in a general report.

Engineering supervision is somewhat difficult to delineate, because it is not the type of supervision normally associated with production and other functions of the organization. A great deal of the time devoted to technical supervision is, in fact, utilized in keeping aware of the status and technical aspects of many projects. Since engineering projects are seldom repetitive, the problem of supervision is continually changing. While it may seem that more technical time is devoted to supervision than may be justified, it is probably true that less supervision of the ordinarily accepted type is required in engineering than in most other functions of the company. By the same token, more planning and evaluation are required.

Any budgeting, scheduling and evaluation system should exact a minimum amount of the time of technical personnel in order to justify its cost. Therefore, after the original estimates regarding a project have been made, the accumulation of time and expense data should be as automatic as possible and be made by clerical personnel, working from the simplest possible standard reports prepared by each individual engineer.

DETAILS OF PROCEDURE

The following procedure satisfies the requirements just discussed. This method has considerable flexibility and can be expanded or contracted, depending upon the needs of the particular engineering organization.

Assuming a technical budget is available or data are being collected to aid in the preparation of such a budget, information must be accumulated in order to allocate engineering time and money among the basic technical functions, and to distribute the time of engineering personnel among the various projects. Chief among the various types of information which contribute to an analysis of engineering economics are figures on the actual number of hours spent by the engineering department on each of the four basic functions already defined. Next in importance is the percentage of the total time available which is applied to each of the four functions. By analyzing these percentages, it is possible to determine whether technical time is being allocated to the proper functions or whether a disproportionately large amount of the time and money is being expended by one of the functions at the expense of others. Another side of the picture which can be checked is whether additional personnel and funds are needed in order to fulfill the duties of the engineering department.

But just knowing the amount of time is not sufficient. The type of time—engineering hours, test hours or model makers' hours—spent on each one of these functions must be known in order to arrive at a truly meaningful total. A means of classifying the various personnel is therefore necessary.

In a small engineering department, it is sufficient to classify each of the personnel under one of the following headings: Research, Engineering, General Laboratory, Experimental and Model Makers, Design and Drafting, General Services and Administration.

This particular classification is also applicable to some medium-sized operations. In such cases, a further breakdown is made for purposes of final costing; at the other extreme, for very small engineering departments, it can be consolidated by combining several of the classifications.

CHECKING PROJECT PROGRESS

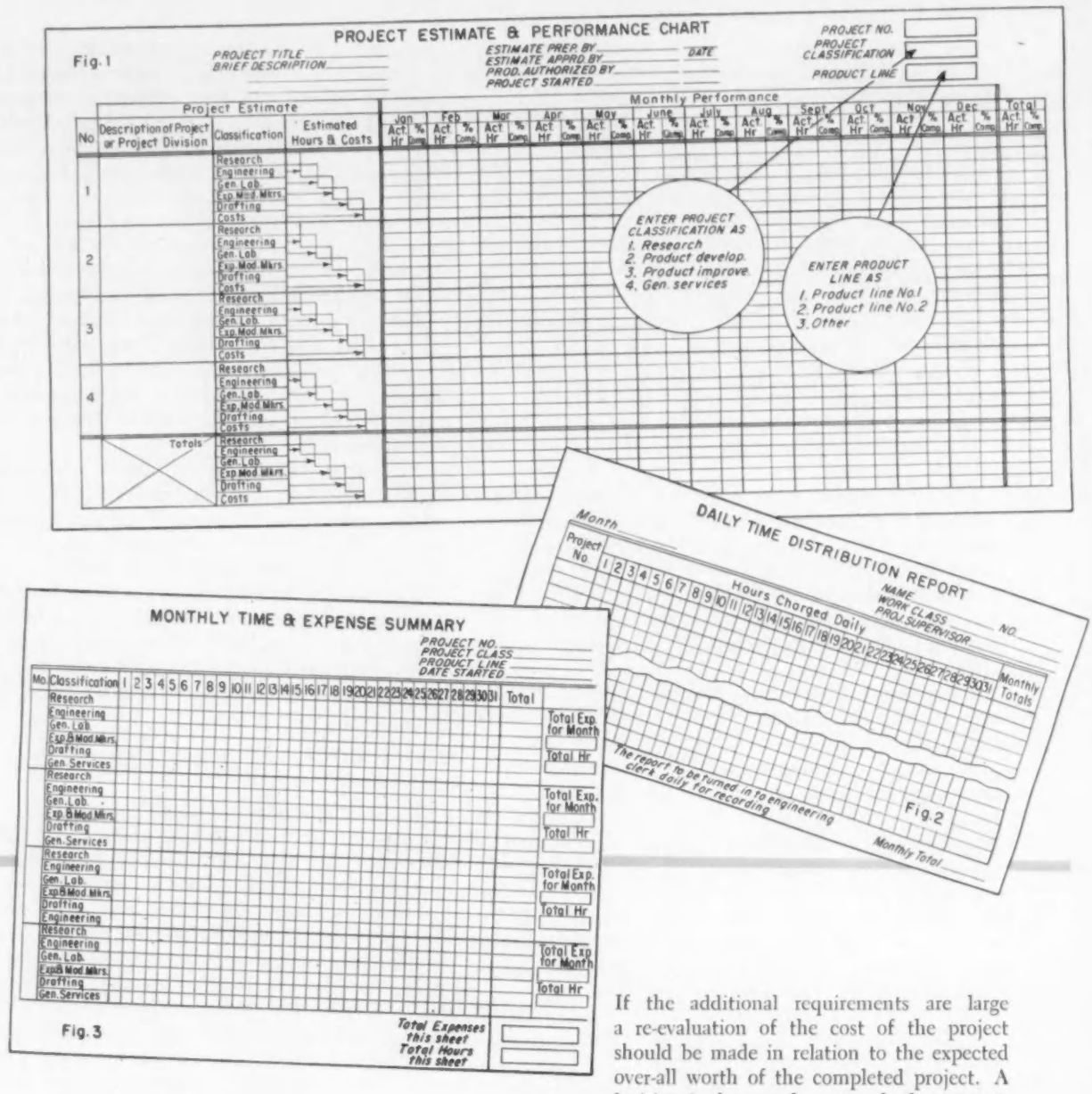
The next important analysis to be made is the estimated progress to date on the various projects. Are they within their estimated time and materials requirements, or are additional funds and/or personnel required?

Before the start of any project, and usually even during the preliminary discussion stage of the project, an estimate of the time, material and out-of-pocket costs required to complete the project must be made. It is sometimes difficult to make such an estimate on projects of a research and development nature, and also in those cases where the engineering department does not have previous project estimates and performances comparisons to use as historical background. If previous project estimates have not been made, there is little that can be done except to set up the system and then accumulate the necessary experience and historical background.

Through periodic checks and references to the original estimate during the progress of the project, the technique of estimating can be learned and a realistic evaluation of the over-all project cost made.

There are also certain types of projects, particularly those dealing with research that cannot actually be estimated to completion. This is because they are of a continuing nature and may give useful or desirable results at various stages of the project, yet may not be completed for long periods of time. In this type of project, it is necessary to allocate a certain amount of technical time and money, and then evaluate the results at frequent intervals to determine whether it is wiser to discontinue the work, or to go on with the project in view of actual results obtained and the promise held out by the investigations made.

One of the most important factors in estimating and

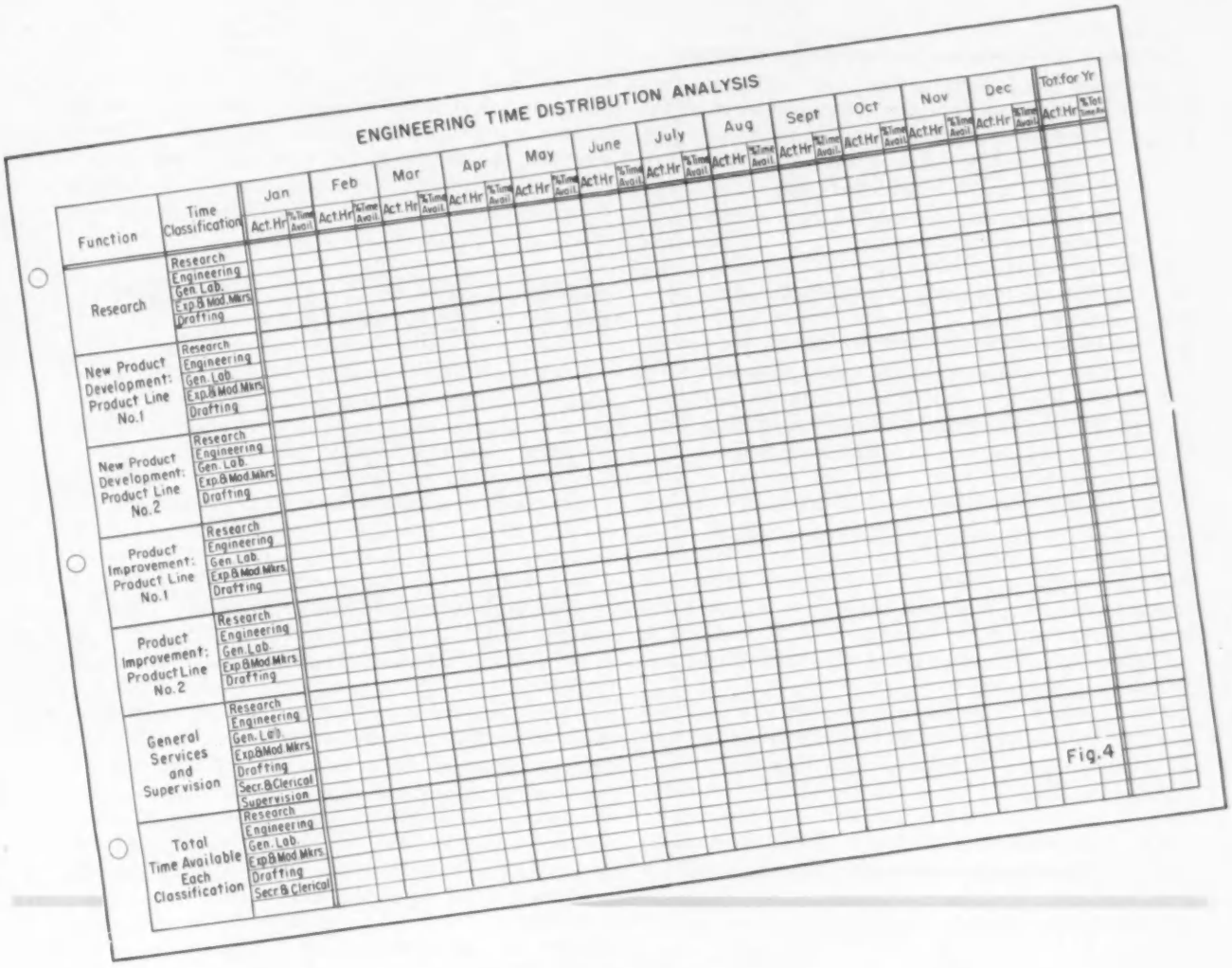


evaluating is a direct comparison of performance with original estimates. In many cases, elaborate estimates of time and money expenditures are made in clear form, but the actual performance is not shown where it can be directly compared with the original estimates. The direct comparison method will, to some extent, reflect the efficiency of the department, but will serve a much greater purpose in promoting realism in the making of estimates and determining where adjustments must be made either upward or downward as a project progresses.

Naturally, in any project, and particularly those of a research or developmental nature, there will frequently occur changes in the objectives and requirements of the estimated work required as a result of data obtained from the experimental work. These changes in the over-all requirements of the project must be recognized as soon as possible and the necessary provisions made for changes in the personnel or money required to complete the project. If the additional requirements are large a re-evaluation of the cost of the project should be made in relation to the expected over-all worth of the completed project. A decision is then made as to whether or not the project should be continued.

The Project Estimate and Performance Chart, Fig. 1, provides a means for making a direct comparison of actual performance with the original estimate. The nature of the project, i.e., Research, New Product Development, Product Improvement, or General Services, should be noted in box marked "Project Classification" at the start of the estimate. This is necessary because the time spent on any given project will be allocated under this particular function in the final Engineering Time Distribution Analysis.

Many companies have more than one line of product and it may be desirable to determine the amount of engineering time and money spent on each product line. This is of value when considering the question of discontinuance of a line or determining why a particular product line has not kept pace with competitors. When it is desired to divide the engineering time in its various classifications among various lines, notations are made in the box marked "Product Line", Fig. 1, at the time it is prepared.



Also worthy of note in Fig. 1 is the provision for keeping track of the type of labor required in each step of the project estimate, as well as the out-of-pocket costs applicable to each step of the project. In addition, on the right-hand side of the chart there is a place for a summary of the time and money actually charged to the project, accumulated at regular intervals, and the percentage completion of the project. This permits an immediate comparison between estimated performance and actual performance.

Though no attempt is made to indicate the particular steps required in estimating and scheduling a project, some of the following steps are: Patent search and study of prior art, analysis of competitive products, preliminary research and design, determination of proposed product specification, experimental breadboard models, model testing, prototype models and production engineering are proposed development.

As mentioned earlier, any estimating and analysis system must be economical of the time needed in its preparation if it is to have maximum value. After the original estimate is prepared, all the data needed for analyzing the status of the project can be accumulated from Daily Time Distribution Report forms, Fig. 2, made out by each person in the engineering department, and a Project Progress Report which shows the percentage of completion of the various steps of the project at regular intervals, usually monthly. The time entries from the Daily Time Distribution Report are then entered on the Monthly Time and Expense Summary, as shown in Fig. 3, for each authorized project. At the end of each month, the accumulated totals from the monthly summary are entered on the Project Estimate and Performance Chart for each project. The direct costs charged to the project, other than time, are entered in the appropriate box each month. The percentage completion of each of the various steps of the project and the project as a whole are determined by the project leader and reported monthly. These percentages of completion are then entered in the appropriate box on the Performance Chart, thereby completing the information needed to determine whether a project is running over or under its budgeted time and expenses in each classification.

Time intervals other than monthly may be used. However, monthly totals are generally suitable except for projects of a very minor nature, and these can often be classified under the heading of General Services in order to simplify recording and paper work. If there is concern about overemphasis of the General Services classification, the answer is readily available in the monthly Engineering Time Dis-

tribution Analysis, which will be described below.

It should be understood that the proposed scheme of accumulating and evaluating time and cost information must be varied, depending upon the requirements of the particular engineering department and, in some cases, even the project. No attempt should be made to fit a procedure either into an existing or a proposed organization. The better approach is to study the application of the principles and determine the specific requirements of the particular organization. A procedure is then developed to satisfy these requirements in accordance with the broad principles already outlined.

At month's end, the amount of time for the various classifications is totaled for each type of project and for each product line, and entered along with the total time available in each classification in the Engineering Time Distribution Analysis, Fig. 4. This analysis shows at a glance on a month-to-month basis the amount of time being applied to each classification of project and product line. It also helps in determining the direction in which the engineering department is going and in making suitable adjustments as dictated by company policy and objectives. In time, of course, the analysis will show the trends of the engineering department for an entire year, and from year to year, thus giving a basis for longe-range forecasting and planning.

The information collected in the manner described can be presented in concise form to show the basic trends of the technical effort as exemplified by the Engineering Time Distribution Analysis, or in varying degrees of detail through use of the Project Estimate and Performance Chart. This information, combined with a brief monthly report from each project leader, will suffice to give all the detail necessary for a good evaluation.

In the analysis of any project, there are several points which frequently cause considerable dislocation and misunderstanding regarding both the costing and scheduling. One of these is the injection into the normal stream of engineering projects of "emergency" jobs which take precedence over established projects. An analysis of the type described, combined with data on schedules, will in many cases make it possible to explain conclusively to other department heads the necessity for keeping these "emergency" projects to a minimum.

Table II—Code Numbers of Engineering Project Classifications for Punch Card Systems.

Product Line	Project Classification
1. Product Line No. 1 2. Product Line No. 2 3. Others	1. Research 2. Product Development 3. Product Improvement 4. General Services
Class of Work	**Department**
1. Research 2. Engineering 3. General Laboratory 4. Experimental and Model Makers 5. Drafting 6. Supervision	1. Research Department 2. Development Engineering Department 3. Production Engineering Department 4. Tool Engineering Department
	Phase
	The numbers 1–9 are inserted here for those projects which are broken up into major steps or phases.

ADAPTABILITY TO PUNCH CARD ACCOUNTING SYSTEMS

Since this particular procedure has been written for the small or medium-sized engineering department, where punched-card accounting equipment may not be available, no mention has been made of the use of this equipment. Accounting systems such as those provided by IBM and Remington-Rand Corporation are readily adapted for making these analyses, and serve as yet another aid in reducing burdensome detail in the engineering department.

To illustrate how the procedure outlined above is adapted to punched-card accounting, consider the list of variables, Table II, which have been discussed. It will be noted that an additional variable labeled "Department" has been added. This is to take care of those engineering divisions composed of more than one department or section. While this is usually not the case in the small engineering department, the medium-sized and larger engineering divisions are frequently divided into departments, along the lines shown. Adding an additional departmental classification imposes no additional burdens on the punched-card type of accounting system and permits a still further breakdown in the engineering analysis.

In coding a project into its particular classifications, a number must be utilized which, by the position of the digits, will indicate the project classification. A typical number is:

501-22323

The first three digits are the serial number of the project; the fourth digit determines the product line; the fifth digit, the project classification; the sixth digit, the project phase; the seventh digit, the department; and the eighth digit, the work classification applied to the project. The number illustrated would therefore represent Project No. 501, which is a project on Product Line No. 2; is a Product Development Project; and the time charged is to Phase 3 of the project. The project is assigned to the Development Engineering Department, and the work applied to the project is of the General Laboratory classification.

The above discussion has been concerned with direct out-of-pocket expenses and hours. It is relatively easy to convert the hours into dollars and add items for overhead, thus giving actual costs in dollars. For the small engineering department, it is usually sufficient to take an average of the salaries of the personnel in each classification for this dollar conversion. This is particularly true where there are small differences in salaries for personnel in the same classification. If greater accurary is required, periodic adjustments can be made for the differences in actual salaries and the averaged salaries.

PLASTER MOLD CASTING

Plaster mold precision castings should be considered when (1) the process can reduce machining time and costs; (2) close tolerances are mandatory; (3) exceptionally clean or smooth finishes are desired; (4) structural characteristics of available plaster mold casting alloys are suitable; (5) the production quantity involved is economical; (6) the size of the casting does not exceed the flask size of the foundry; (7) complicated shapes or thin sections (to 1/16 in.) are required; (8) and there are design and assembly advantages derived from reliability and uniformity of all cast parts.

R. B. ANDERSON
President, Atlantic Casting & Engineering Corp.,
Clifton, New Jersey

PLASTER MOLD CASTING provides a means for securing any desired quantity of accurate reproductions of a pattern by preparation of a series of identical, expendable plaster negative molds of the original pattern. From these plaster molds, in turn, positives may be cast in a wide variety of non-ferrous metals.

THE PROCESS

Our process begins with the preparation of very precise brass patterns, similar to certain sand casting patterns except that tolerances can be held to less than 0.002 in.

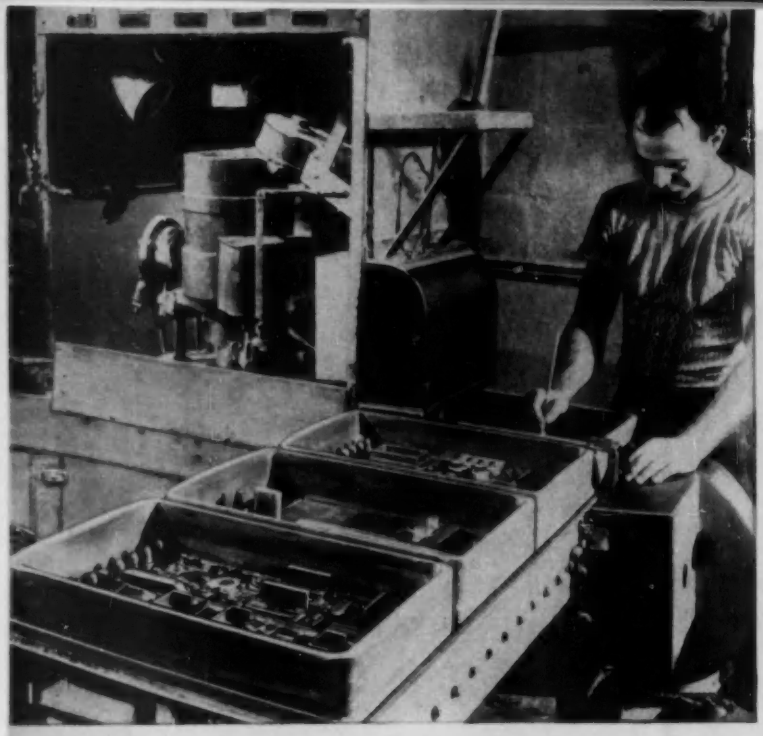
The pattern is prepared in split style, each half mounted on a special type of mold board precisely subdivided by interchangeable sections—unit strips. A flask size of 11½ in. x 17½ in. is divided into 20, 1¾ in. x 5 5/16 in. strips mounted in rows of ten each. A single die pattern may be so small that one strip will accommodate several patterns of the same piece. In other cases, a pattern may require several strips for mounting, or may even use all 20 strips and occupy the entire pattern area of the container.

The strip mounted patterns are placed in the flask rim so that all the space is occupied. A runner for the metal and gates to bring the metal to each part is also contained on the strips. When the required number of plaster molds have been made from any particular pattern, the strip or strips on which the pattern is mounted may be removed from the flask, and another pattern of the same strip size substituted. The entire replacement operation takes only a few minutes. A short run for a particular casting may thus be made without materially interfering with the longer run of other castings in the same flask, thus providing for economical small lot production.

Plaster molds of the patterns are made by automatic machines which, after application of a parting agent, Fig. 1, deposit a slurry of plaster and water on the face of the patterns in a flask. Another machine properly agitates the flask. Then, with minimum movement and vibration, the flask rotates about a circular setting table while the final setting action takes place.

An automatic pneumatic machine rapidly removes the wet firm plaster mold from the flask without vibration, as shown in Fig. 2, thus maintaining its accuracy, reproducing all the details of the pattern even including scribe lines left by the pattern maker. Lettering, small gear teeth, indents and details normally lost with rougher casting methods are clearly impressed in the mold for later reproduction in the casting.

While making the plaster-mold, a similar process with more hand control goes on to mold any loose cores which are required for a particular casting. The small individual cores are fed into a continuous drying oven together with the wet mold, as shown in Fig. 3. The water in the slurry is uniformly removed and, in addition, the mold is calcined by the regulated heat to a sufficient depth so



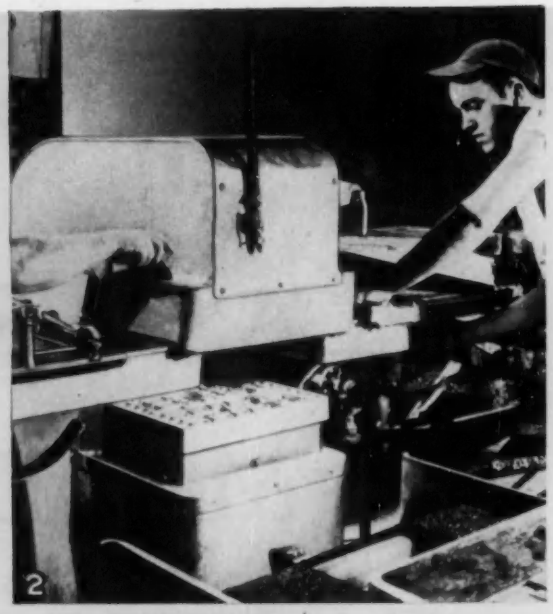
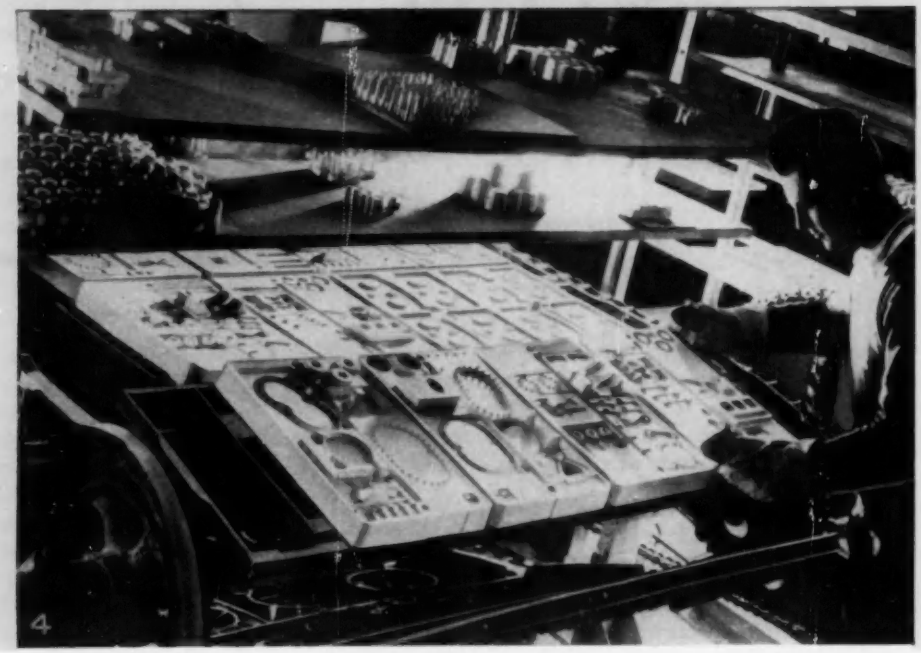


FIG. 1—Flasks with die patterns in position are sprayed with parting agent and automatically poured with plaster and water slurry.

FIG. 2—Non-vibrating pneumatic device smoothly extracts set mold from flask.

FIG. 3—Continuous type drying oven removes all moisture from mold and calcines surface to eliminate gas formation during pouring.

FIG. 4—Ten-mold truck at pouring stand showing asbestos lined sprues.



that when the molten metal comes into contact with it, there will be no evolution of gas.

Casting and Finishing come next. Following calcination, the loose cores are inserted in their proper positions in the molds, as shown in Fig. 4. The molds are then assembled, top with mating bottom, in standard cope and drag fashion. Since the method of pouring and extracting the molds eliminates outside supports, hard plaster dowels are used between the cope and drag, rather than flask pins. Asbestos pouring sprues are inserted in the mold, as shown in Fig. 5, and groups of ten molds are trucked over to the pouring area for placement in a pouring jig which holds each individual mold assembly together under uniform pressure. This insures uniformity of vertical dimensions and prevents accidents during the pour. The non-ferrous alloy melt is removed from the furnace in a crucible and carried to the pouring station. (In general, the molds in the jig are all taken from the same patterns and all take the came casting alloy.) The crucible proceeds to the pouring stations without agitation for fluxing, skimming and final temperature check. The same device that conveys the crucible to the pouring stations also carries the crucible to each individual mold for pouring, as in Fig. 6. After the pour, there is an extended cooling period while the molds remain under the pressure plates of the pouring jig. If the castings in process require the use of vacuum or air pressure, these means are also employed during the pouring period.

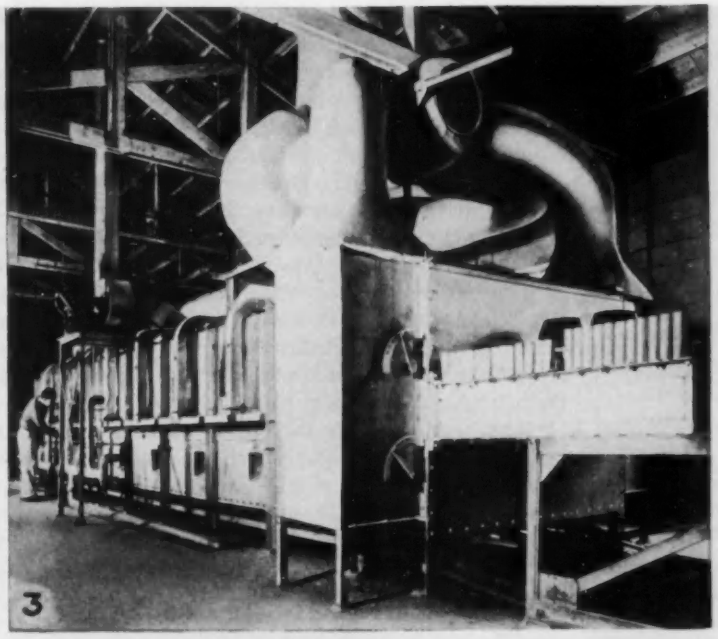
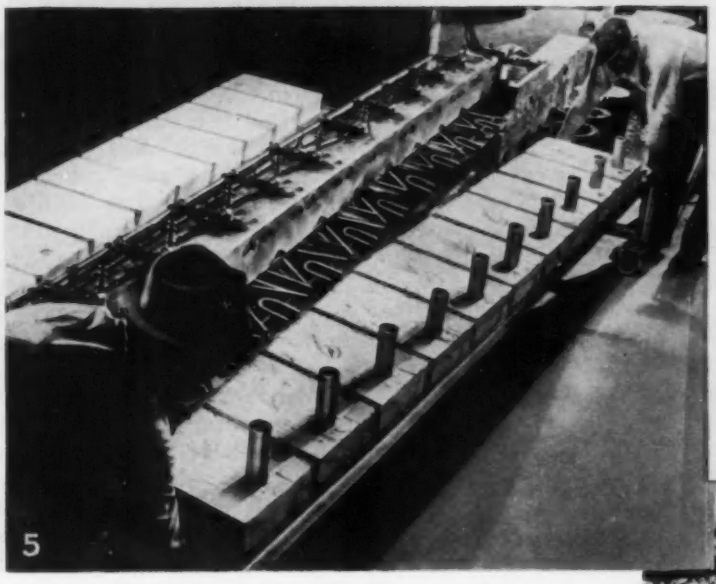
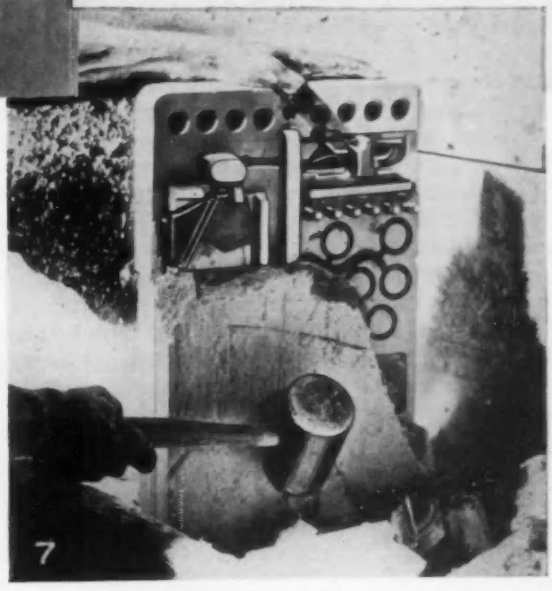


FIG. 5—Loose cores are inserted in fully dried, hard surfaced molds.

FIG. 6—Recording pyrometer determines proper moment for pouring; one-man pouring monorail permits accurate control.

FIG. 7—Castings are removed by breaking up mold after cooling.





The cooled molds are wheeled from the pouring stand, and the castings are removed by breaking up the friable plaster, as shown in Fig. 7. The molds have served their purpose and are now waste. A pressure spray removes all remaining plaster particles.

Because of the sharp definition and accurate dimensions of the castings, practically no additional finishing is required other than the separation of the individual cast parts in a complete gate. Using abrasive cut-off wheels, operators separate each cast element and also remove gates, runners, shrink bobs, fins, and other extraneous elements accompanying the casting process. Sand blasting gives final finish, after which the castings are already for packing and shipping.

Characteristics of Plaster Mold Castings

1. Blow holes and porosity are eliminated; thus, castings will not arrive at the finishing process with a defect which scraps all prior work.

2. Elimination of hard spots increases tool life.

3. Castings from the same die are completely uniform and will fit jigs without additional adjustment.

4. Where machining is necessary because final tolerances are closer than can be cast, material to be machined will be a minimum. In general, the dimensional tolerance and smooth clean finish of the castings meet ordinary machining tolerances and thus reduce or eliminate further machining or finishing.

5. Complex designs are produced by using loose cores. Complicated assemblies including stops, internal teeth, and blind gear teeth can be cast in one piece. Thin sections down to 1/16 in. thick can be cast for substantial weight savings.

HOW STEPS IN PROCESS AFFECT END RESULT

Factors which determine selection of the plaster mold casting process depend, in final analysis, upon the care, attention, or special techniques used at each stage of processing.

Original Pattern. The pattern maker must be an artisan as well as an exacting worker. Thorough knowledge of the casting process, plus a creative insight into best manner for preparing two pattern halves which, between them, will produce the desired cast part, are required. The design and shape of each individual pattern, the core requirements, if any, and similar matters must be determined to produce the part to desired specifications. Brass is generally chosen as the die material since it is easily worked and modified, yet has the necessary hardness, corrosion resistance, and dimensional stability to hold the 0.002 in. tolerance. Also, the life of a brass pattern is practically unlimited since the soft plaster molding slurry subjects it to neither abrasion, pressure or thermal shock. Seldom is it necessary to replace any brass patterns; some in daily use for seven years show no signs of wear. The mold material actually tends to polish the pattern. Alterations to the original pattern are easily made should changes he required in the specifications of the completed casting. Where desired, wood or plastic patterns may also be used, although life expectancy and precision will not be as good.

Split Pattern Technique. The unit strip system is primarily a cost influence, permitting more competitive pricing of the final product along with flexible use of patterns. However, it does have certain qualifications. Since all individual parts in the same flask are poured with the same alloy at the same temperature, they must be compatible with each other in this respect. In commercial small lot production, it has been necessary to limit the number of alloys used to four—two copper-base and two aluminum-base—to insure full use of all space in each flask. Where a run permits handling of patterns on a full-flask basis, a wider selection of casting alloys is economically feasible.

Preparing the Mold. Essentially, the plaster mixture, pouring, setting and extracting techniques determine the detail accuracy of the plaster mold, and hence the accuracy of the process. Casting gypsum is used for the slurry, the only special requirement being automatic control of the mixing and pouring. The surry must be mixed with water, measured and poured in fast sequence since the material sets rapidly. The time for each stage, as well as the water temperature, is carefully controlled. Agitation time is regulated according to the flask size used and is the major control required to insure removal of all air bubbles from the pattern face, porosity, and thorough investment of the pattern such that the plaster penetrates every fine detail. The length of the entire molding cycle is just long enough to deposit the slurry and permit it to set sufficiently for extraction without breakage. The exact time is regulated by experience but must be consistent to hold maximum detail and provide uniform consistence in the molds. It is unnecessary to incorporate draft angles on the outside surface of the castings, while draft normally can be held to 1 deg or less on inside surfaces. Perpendicular outer edges will be true; inner corners need vary from a right angle by only a slight amount.

The mix proportions of gypsum to water for the loose cores depend on the size of pieces involved. All factors are established so that both cores and molds come out of the drying oven uniform in porosity, strength and degree of hardness.

Drying. The heating characteristics of the oven are regulated to provide additional permeability in the mold. This additional protection is required so that any gas which may be trapped in the mold or which may have been generated during some part of the pouring operation will have freer access to the air. Surface calcination of the mold provides further protection from gas bubbles and a smooth finish on the plaster which will hold all the detail of the pattern.

Casting. Control over the casting operation begins with the original mixing of the alloys. Composition of alloy ingots to meet rigid specifications is most important. Contamination is then best prevented through continuous good housekeeping in every part of the plant, and includes careful re-use of scrap and accurate makeup of a heat.

The pouring temperature depends on the specific alloy in use and the type of pattern used in any particular set of molds, and must be regulated carefully. For this purpose, a recording pyrometer checks the temperature of the metal in the crucible before and during pouring.

The porous gypsum mold makes a good insulator, allowing the casting metal to fill the mold cavity completely before it starts to freeze, thus permitting the escape of any entrained gas. The resulting casting is sound, free of internal stress and without skin hardness; its surface is comparable to die casting in smoothness and superior in smoothness with certain aluminum casting alloys. A finish of 125 microinches is typical. Close control of the pattern dimensions, together with regulated pressure on the molds

during pouring and cooling, sharply cuts down finning and results in a minimum of cleaning and finishing. Shrinkage is negligible, requiring no precautions for smaller pieces. For larger castings, shrink bobs feed the casting.

In general, plaster mold castings may successfully be produced in any size from fractions of an inch in the short dimension to several feet in the long dimension. Tolerances obtainable in either aluminum or copper-base alloys are comparable to ordinary machining limits on dimensions of ¼ in. to 3 in. Dimensions in this region, when cast from one side of the parting line, are supplied to tolerances of 0.005 in., with tolerances for larger dimensions increasing at the rate of approximately 0.002 in. per in. Precision regulation of the molding and drying operations also insures good stability in across-parting-line dimensions. However, vertical dimensions extending across the line cannot be held as closely as those which are all made from one side of the mold. For certain commercial purposes mismatch along the parting line, not exceeding 0.015 in., is permitted without causing rejection. Generally, mismatch is held to less than one-third of this figure.

CASTING MATERIALS

Characteristics of casting alloys which meet most requirements are shown in Table I. In addition to the alloys shown, other aluminum manganese bronzes, aluminum bronzes, a wide range of brasses, silicon bronzes and a few special nickel bronzes are poured regularly and successfully.

Manganese bronze alloy is superior for high strength applications. As cast, this alloy tends to work harden slightly in use. After a period of initial usage, and where there is no visible wear on the casting, dimensions of the part do not change; and the physicals remain essentially constant for millions of operating cycles of impact or rubbing. Performance figures shown are not duplicated by other methods of casting since the uniform, sound grain structure of the material results from its production with plaster mold casting techniques. While this alloy makes a tough casting, it handles easily, drills and taps readily, and can be milled with ordinary high-speed tools.

Aluminum Bronze Alloy No. 2 Special is a zinc-free alloy especially developed for high strength applications. When plaster cast, it is strong and tough and can attain, on heat treatment, ultimate physical properties in excess of 125,000 psi with no appreciable reduction in elongation. In heavy sections fine detail will not be as good as with other alloys, but it presents an attractive appearance and meets all ordinary requirements for precision castings.

Yellow brass is one of the oldest casting alloys. It is typified by ease of machining, bright surface on a machined face and complete uniformity from skin to core.

Aluminum Alloys present a special problem when handled by plaster mold methods. Sections ¼" or less meet standard sand cast values in both Numbers 355 and 356 in the T6 condition. Heavier sections show some evidence of a slightly enlarged grain structure due to the insulating characteristics of the mold which slows the cooling rate. Physical values for the heavier sections are somewhat lower than standard sand cast values. Superior handling and pouring techniques are employed to obtain the highest physical properties. Successful results are also obtained with the high strength aluminum alloys which require no heat treatment. Alloys such as Tenzaloy will after a natural aging period exhibit physical characteristics completely satisfactory for many stressed castings.

The upper temperature limit of the plaster molds is about 2200 F. Ferrous metals, and some non-ferrous alloys having a very high pouring temperature such as some nickel bronzes and alloys with a very high lead, tin, or copper content will not cast to best advantages in plaster.

Table I—Alloy Specifications

Alloy →	Yellow Brass	No. 1 Special Aluminum Bronze	No. 2 Special Aluminum Bronze [1]	High Tensile Manganese Bronze	High Strength Aluminum [2]	Aluminum Alloy [3]
Nominal Physicals As Cast (approx.)						
Ultimate Tensile	50,000	70,000	85,000	100,000	26,300	
Yield Point	25,000	40,000	52,000	60,000	19,500	
Elongation Per Cent in 2 in.	12	7.0	4–6	7.0	6.0	
Brinell	100	160	180	190	.....	
Patterns Required	Open Flask	Full Flask	Full Flask	Open Flask	Open Flask	
Nominal Composition (approx.)						See Note Below
Copper	58.00	82.50	78.0	65.00	0.8	
Zinc	40.25			23.00	8.0	
Tin	1.00					
Lead	.75					
Aluminum		11.25	10 5	5.00	Balance	
Iron		5.00	4.0	2.50		
Manganese		1.25	1.25	5.00		
Nickel			4.0			
Silicon						
Magnesium					0.4	

[1] Heat treating No. 2 Special Aluminum Bronze gives the following Physicals: Ultimate Tensile 125,000; Yield Point 75,000; Elongation 5 to 6 Per Cent in 2 in.; Brinell 260.
[2] Results obtained from test bars aged two weeks at room temperature.
[3] Alloys #356 & 355 in ¼" sections or less in the T6 condition meet guaranteed values for sand castings. Values for heavier sections are somewhat less.

Table II—A Few Plaster Mold Casting Applications

Type of Service	Application
Aircraft and Marine	Instruments and controls, hydraulic system parts, flanges, fittings, flap hinges, wing nuts, pistons and cylinder heads, impellers and propellers.
Automotive	Chassis, body and engine fittings, gears, ornaments, bearing retainers.
Appliance	Small appliance casings, washing machine parts, vacuum cleaner parts, cooking utensils, appliance hardware and decorations.
Electrical	Brush holders, wire connectors, cable clamps couplings, transmission line connectors and pole line hardware, sparkless tools.
Electronic	Microwave and radar components, tuning gears, operating mechanisms and frames.
Industrial and Hardware	Wrenches, pliers, clutches, sprockets, hinges, valves, fittings, impellers, control levers, springs, miscellaneous plumbing supplies.
Railroad	Locks, handles, lighting fixtures, gears, ornamental, plumbing and miscellaneous hardware.
Miscellaneous	Surgical instruments, toys, plaques and insignias.

COMPARISON WITH OTHER CASTING METHODS

Recognizing that local factors often affect selection of a casting process, some general characteristics should be considered for the various processes, including sand casting, investment casting, shell molding, die casting, and permanent-mold casting.

Sand Casting. Both piece price and die cost are generally higher for plaster mold castings than for sand castings. Thus, plaster mold castings are more suitable where higher precision and retention of detail are required. The smoother surface finish obtained with plaster mold casting make it more economical in those cases where considerable machining of sand castings would be required.

Investment Casting techniques are still limited to production of relatively small parts; although a greater range of alloys, including the ferrous types, is available. The two processes are therefore not always directly comparable, each being able to produce some parts the other cannot. However, where a part can be produced with either process, plaster molding will be found more economical in the piece price, and approximately equal in die costs. The order of precision is roughly the same for both casting methods.

Shell Molding. Direct comparison with shell molding is more difficult. For small quantities, the piece and die prices for plaster molding are usually less. However, if the greater tolerances and rougher surface finish inherent in shell molding are acceptable, then it may be more economical when the quantities are large enough to absorb the higher pattern costs and allow for the gating problems to be ironed out. Since shell moldings accent ferrous alloys, the plaster process is not competitive in this regard.

Die Casting. Die casting copper base alloys is practical where the material has a relatively low pouring temperature. This applies to certain brasses, zinc alloys and aluminum. The use of die casting for alloys having the higher pouring temperature characteristic of high tensile materials is limited because of the resulting shortened die life. With aluminum, the choice is based on the shape of the part and the required quantity. Plaster molds permit use of more complicated shapes and intricate core structures, as well as thinner sections. A plaster mold die may cost only one-third the price of a single impression die casting die. However, the piece prices of plaster mold castings are higher. Experience indicates that in quantities from a hundred to a few thousand, the plaster mold process will be more economical.

Permanent Molds. These also experience relatively short die life with copper base alloys. However, the method is highly advantageous for large pieces which do not lend themselves well to mechanized plaster molding. Permanent mold castings are generally less critical in their dimensional and surface finish requirements. As a result, there are relatively few pieces which can be handled successfully by both processes. In addition to die cost and the piece prices, tool life, rejects, and satisfactory performance of the end product are important factors in selecting a casting process. Plaster casting is generally superior in these factors.

INDUSTRIAL ACCEPTANCE

Increased use by industry of the plaster mold process may be attributed partially, at least, to the steady rise in machining costs and the growing dearth of skilled machinists. Since plaster mold castings hold ordinary machining tolerances, their use can effect considerable labor savings —both in machining and assembly. Increased mechanization of the plaster casting process, with resulting closer control over every step, has provided less costly casting of greater reliability so that more companies have found it advantageous.

As the potentialities of the process are better understood, further use of plaster mold castings will undoubtedly result. In many instances a conservative design policy tends to ignore the possibility of using non-ferrous alloys. Of course, there are cases where only steel will serve the purpose; and as other casting processes make ferrous alloys available in precision castings, there will be some encroachment on the plaster mold field.

PRESENT APPLICATIONS

A partial list of applications for plaster mold castings is given in Table II. Parts that have been successfully cast are numerous; therefore, the selection was made from among heavy alloy parts, used where durability and high strength are needed—rather than from aluminum and other light alloy plaster mold castings with which designers and industrial users are perhaps more familiar. (See *Product Engineering*, September, 1954, "Plaster Casting the Light Metals", by George R. Gardner.)

The York Corporation's original design of an ice cutter for their automatic ice maker contemplated the machining of three separate stainless steel parts, to be joined by an additional welding operation. Instead, it was found possible to cast the entire part in one piece, comprising six spiral blades on a center shaft, Fig. 8. Manganese bronze was selected, to provide necessary endurance and strength, as well as the corrosion resistance and retention of smooth surface finish required in food equipment.

An aircraft generator brush holder developed for the General Electric Company, with their collaboration, was another interesting design. The company's older model, Fig. 9(A), machined from steel, added objectionable weight and cost, but seemed necessary for strength. The part was completely redesigned so that it could be produced as a one piece casting, Fig. 9(B). Manganese bronze was used to provide adequate rigidity, despite an 0.076 in. minimal wall dimension in the new brush holder. The cost of the casting was substantially lower than the machined parts it replaced.

Specifications for the skirt door operating mechanism on cars for the Pennsylvania Railroad, manufactured by the Budd Company, have been based on the necessity for them to absorb continuous punishment. When plaster-mold cast in manganese bronze, Fig. 10, each separate part provided a tensile strength of 100,000 psi and a Brinell hardness of 190 without any additional heat treatment. Also, by using an assembly of plaster-mold cast parts, no machining was required, the installation being reduced to the drilling of two holes.

EDITOR'S NOTE—Reference is made to a previous article, "Plaster Castings The Light Metals" by G. R. Gardner, on p 164 of *Product Engineering* for Sept. 1954. This article gives additional design considerations, including data on dimensional tolerances, a discussion of some additional casting alloys with test data on mechanical properties, methods of finishing, and mention of several other applications for the plaster mold process.

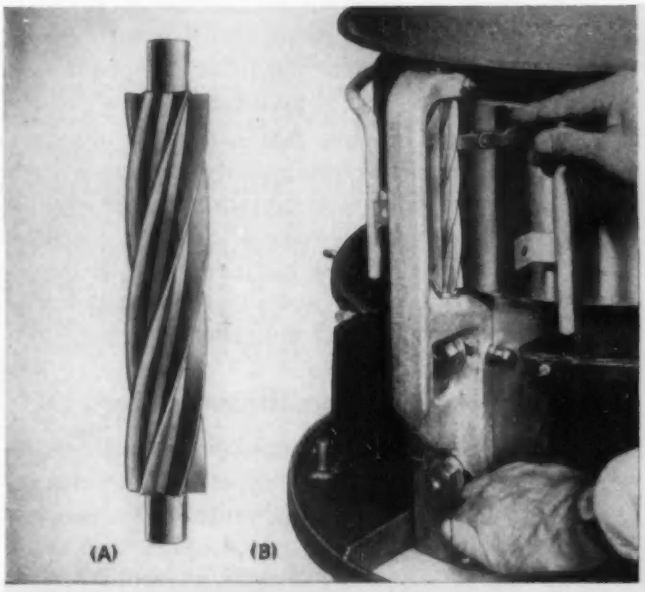


FIG. 8—(A) Six spiral blades on center shaft of ice cutter were cast in one piece, replacing contemplated design using three machined and welded stainless steel parts. (B) Ice harvesting system in automatic ice maker showing ice cutter casting in position. Spiral cutter shaves ice into curved flakes, avoiding ice splinters.

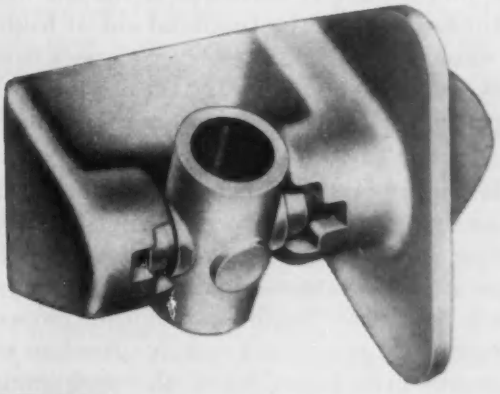


FIG. 9—(A) Original design of brush holder for use on aircraft generators, using several machined steel parts. (B) Newly designed one-piece manganese-bronze cast brush holder provides adequate rigidity.

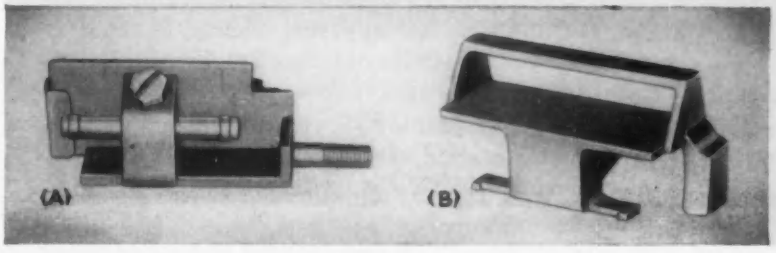


FIG. 10—All parts in this skirt-door operating mechanism for Pennsylvania Railroad cars, were cast by the plaster mold process in manganese bronze. No machining was required for assembly of parts; only two holes were drilled to complete installation.

FINANCIAL AID TO HIGHER EDUCATION

Business Aid for Our Colleges — Voluntary or Involuntary?

Previous editorials in this series have shown that:

- As a group the nation's independent, privately endowed colleges and universities are in grave financial trouble, and
- There are many different means by which business firms can extend a helping hand to these institutions.

This editorial, one of a series devoted to the financial problems of higher education, submits this proposition: **If business firms do not voluntarily go to the financial aid of higher education, there is every prospect that they will soon be providing more financial support for higher education involuntarily, through taxation.**

If this prospect materializes, one of the basic elements of a well-balanced system of higher education — a strong array of independent colleges and universities — may well be dangerously weakened if not destroyed. And in the process a potentially crucial bulwark for freedom of enterprise in the United States—that same strong array of independent colleges and universities — will be undermined.

Acceptance of these propositions implies absolutely no disparagement of tax-supported colleges and universities. These have an indispensable role in the total system of higher education in the United States. Leaders of these institutions would be among the first to agree that their position is strengthened by a strong system of independent institutions, supported privately rather than by political agencies.

What is the evidence that in one way or another, voluntarily or involuntarily, business will be giving more financial support to higher education? One impressive part of this evidence is provided by the recent rapid increase in the proportion of college and university students attending tax-supported institutions.

Rapid Shift in Enrollment

In the fall of 1952 tax-supported colleges and universities enrolled about 7.5 per cent more students than the independent institutions. In 1953 this percentage was doubled. And in 1954 the tax-supported institutions enrolled 26 per cent more students.

In the case of students entering college for the first time the relative growth of the tax-supported institutions recently has been even more striking. In 1952, the number of beginning students in the tax-supported schools, as reported by the U. S. Office of Education, exceeded those in the independent colleges and universities by 35 per cent. In 1954, just two years later, this figure jumped to 49 per cent.

Why has the proportion of students attending tax-supported colleges and universities been in-

creasing so rapidly? There are many reasons. But a dominant reason is that, in order to keep going at all, the independent institutions have been forced to make large increases in the prices they charge for instruction. The purchasing power of their endowment funds has been cut in half by price inflation. The capacity of the wealthy to supplement their endowments by gifts, as they have done in the past, has been greatly reduced by high taxes. As a result these schools have been forced to rely increasingly on higher prices for instruction (tuition as it is called in academic circles) to make both ends meet.

Since 1940, the independent colleges and universities have raised their tuition fees by an average of about 60 per cent. This is considerably less than the increase of about 100 per cent in prices generally since 1940. And it is nowhere near enough to prevent the faculty members of the independent colleges from faring miserably in terms of salaries, a matter of major national importance to which we shall return in this series. But the increase in tuition fees of the independent colleges has been much greater than the increase in the fees charged by the tax-supported schools. And that price differential increasingly tends to shunt students into the schools which are supported chiefly by taxes. Independent colleges now charge, on the average, about $580 per year for a full course of instruction while the tax-supported institutions charge, on the average, about $240.

Bigger Tax Bill in Prospect

A large increase in the total enrollment in our colleges and universities during the next decade is in prospect, particularly when the great increase in births during World War II is reflected in the number of young men and women of college age. With a total of 2.5 million students at present enrolled in our institutions of higher learning, it is estimated that the total will be over 3 million by 1960.

If this trend continues most of the anticipated increase in college and university enrollment will be concentrated in tax-supported institutions. Indeed, if the shift toward tax-supported institutions that has occurred in the last three years were to continue over the next six years at the same rate, about two million of the three million students anticipated in 1960 would be in tax-supported colleges and universities and one million in independent schools. In 1950 there was a 50-50 division in enrollment. This shift would mean, of course, a corresponding increase in the tax bill for tax-supported education. And of this bill, we can be sure that an ample share would be assessed against business firms.

No Easy Solution

The best way, of course, to put a brake on a soaring tax bill for higher education is to help the independent institutions get in shape financially to carry a larger share of the student load. For most companies the development of a mutually satisfactory program of financial aid for higher education is a complicated process. In fact, it is so complicated that some companies with an initial disposition to provide financial help are inclined to despair of working out a mutually constructive plan.

If, however, the leaders of business will contemplate seriously the only available alternative to their extending voluntary help to our independent colleges and universities, their determination to work out a plan will be strengthened. For that alternative involves a grave weakening of our system of higher education, together with an involuntary increase in the financial support of higher education by business. The increase would come through higher taxes. Contemplation of such an alternative should, if necessary, toughen the will of business firms generally to do everything possible to extend financial help to our independent colleges and universities.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY, INC.

TECHNICAL NEWS

A New Twist In Suspension Systems

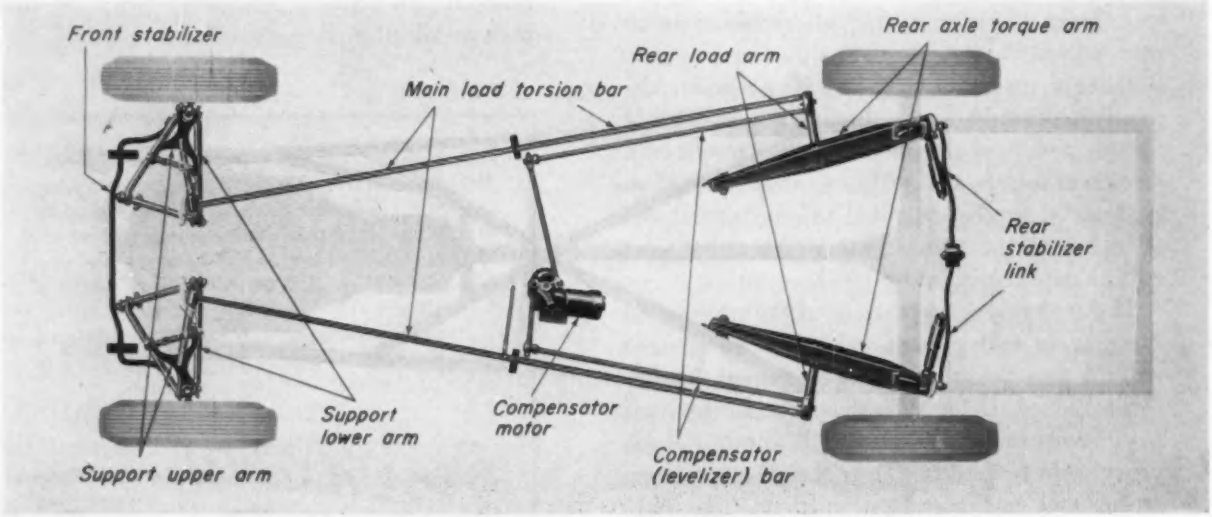
THE PACKARD PATRICIAN featuring the new suspension system and a 260 hp, v-8 engine. The torsion bar suspension system, which gives better rear wheel traction and headlight aiming, is standard equipment in the new Packard lines.

Something new in automobiles this year, other than the customary increases in horsepower and length, plus additional chrome, is Packard's torsion bar suspension which they call the Torsion-Level Ride. Actually, the torsion bar system is not new to the automobile industry. Versions of it have been used for years on foreign sports cars. Porsche had it on its racing car in 1938, and it has been on its passenger cars in recent years. Also, years ago the British Vauxhall had it.

The American automobile industry has been experimenting with the torsion bar for years, but always ran into trouble at the point where the ends of the torsion bar connect to the wheel arms. Previous methods of connecting were by slot and key, or milling down the round shaft to a square or hexagonal shape, all of which reduced the strength at that point, resulting in consistent failures. Packard's answer to this problem was to upset the ends of the torsion bar for added strength, and mill it to a hexagonal shape. To date no failures have been reported.

Packard torsion bar is also different in that only one bar runs the entire length of each side of the car. Various versions of some of the foreign cars have had a short torsion bar for each of the front wheels, and leaf springs in the rear. Still others had a short torsion bar for each wheel. Packard's version eliminates both the coil springs in front, and the leaf springs in back.

As can be seen below, the new torsion bar, made of manganese steel over 9 ft. long and about ¾ in. in dia., runs from the frame front cross member of the chassis to the rear axle torque arms. Load arms are attached to both ends of the torsion bar to transmit the rotary motion of the arms into a twisting action of the torsion bar. At the front, the arm extends outward to the front wheel. So, when the front wheel moves up as it goes over a bump, the resulting twist in the tor-



A SUSPENSION SYSTEM without coil springs in front and leaf springs in the rear. Shown in the diagram above are the necessary components of Packard's Torsion-Level Ride suspension system. Bottoming on the rear axle is prevented with this unit.

sion bar transfers the load, and the rear load arm exerts pressure in the opposite direction, causing the loading on the rear axle torque arm to be increased in a downward direction. Thus, most of the road shock is confined to the torsion bar and is not transmitted to the frame.

The rear axle is connected to the frame through two driving torque arms. It is maintained in proper transverse location by the two rear stabilizer links, permitting free vertical movement of the body without transverse movement between the rear axle and chassis.

Besides the torsion bar, Packard added a load compensator, or car-levelizer to keep the body on an even keel regardless of passenger and luggage loads. This system has two additional torsion bars, about half the length of the main torsion springs, which are attached to the rear load arms. The front ends of these torsion bars are connected to an actuator lever and compensator gear box in the center of the chassis. The gear box is operated by a two-way actuator electric motor which operates from a switch near the compensator motor. This switch is connected to a lever attached to the main torsion bar on the left side of the car. A delayed action of the compensator switch is designed to prevent operation of the compensator motor when the car is going over a bump in the road.

For example, if loading at the rear is increased, it will cause the full length of the torsion bar to twist, and the center portion of the left spring to rotate, causing the lower lever connected to the control switch to rotate. After about six seconds, the control switch makes contact, starts the compensator motor and increases the loading on both compensator bars. This raises the rear end of the car, making it level with the front end, after which the control switch automatically stops compensator motor.

ASME Celebrates Its 75th

On February 16, 1955, The American Society of Mechanical Engineers celebrates its 75th anniversary with an all-day conference devoted to the theme, "The Engineer and the World of Communications." This year's meeting, to be held in New York City, will begin with a morning session in the offices of the McGraw-Hill Publishing Company, for it was on February 16, 1880 that some 30 of the nation's leading mechanical engineers gathered in the offices of "American Machinist," published by McGraw-Hill, to discuss plans for the establishment of an organization for the "collection and diffusion of definite and much needed information." Panel sessions in the afternoon will be: the engineer's communications with those outside his profession; the engineer's communications with other engineers; the engineer's personal communications through writing and speaking.

At the evening banquet and meeting Vannevar Bush, president of the Carnegie Institution of Washington, will speak on "Communications—Where Do We Go From Here?"

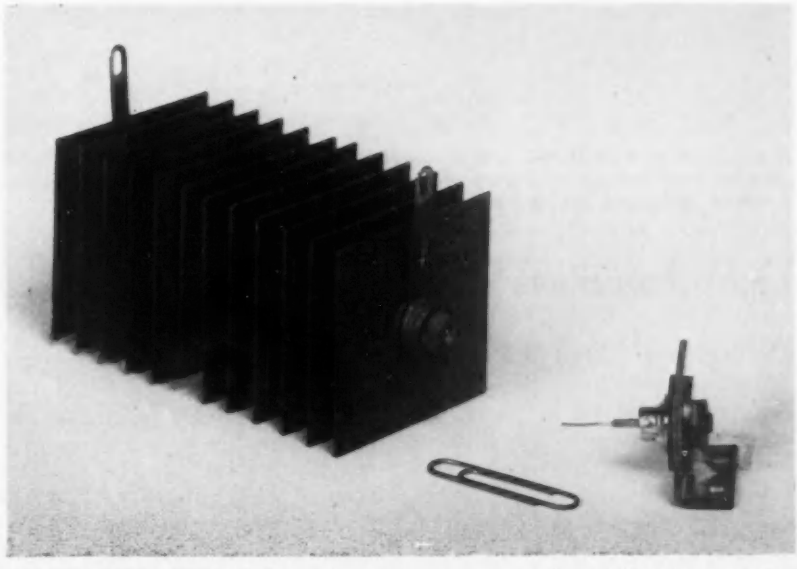
This is the first of five national meetings scheduled in celebration of the Society's 75th anniversary. Others to come are: (2) April 16th, Stevens Institute of Technology, Hoboken, N. J.; theme: "The Engineer and the World of Education." (3) April 18-22, Baltimore, Md., Spring meeting devoted to the theme of "The Engineer and the World of Government;" (4) June 19-23, Boston, Mass., semi-annual meeting; theme: "The Engineer and the World of Science;" (5) Nov. 13-18, Chicago, Ill., annual meeting; "The Engineer and the World of Commerce & Industry."

Silicon Rectifiers to Aid Miniaturization

Experimental silicon power rectifiers, manufactured by the Transitron Electronic Corp. of Melrose, Mass., under an Army Signal Corps contract, indicate improved performance and reliability of future military communications equipment. According to Dr. David Bakalar, President of Transitron, "The new silicon rectifier has promise of being technically superior in every important respect to existing rectifiers, including selenium, and may open up new fields of application."

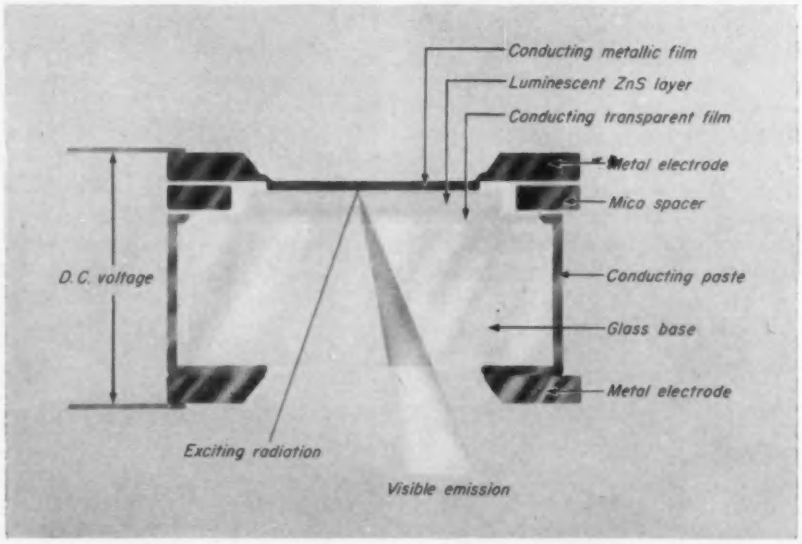
Silicon rectifiers can operate efficiently between 150 C and −60 C, and have large power handling ability. They can be made very compact, and savings in weight and volume will make them adaptable for communications in aircraft.

Theoretically, silicon rectifiers should have infinite life, as there is no filament to cause loss of emission as vacuum tube filaments do, nor do they have the continuous aging effect of selenium rectifiers. Because of their low losses, operating efficiencies are as high as 98 per cent.



CONTRASTED WITH the conventional selenium type rectifier at left is the new small, needle-nosed, silicon power rectifier on the right.

AT RIGHT is what a picture looked like when projected on a screen with a lantern-slide projector, and an ultraviolet light source. At left is the same picture, with the same light source on the same screen—only this time the special phosphor screen has received an electrical charge resulting in a picture about ten times brighter.



A SCHEMATIC DIAGRAM showing the elements which go to make up the special phosphor cell. During the gradual brightening of the projected picture, the contrast remained unchanged, showing that the amplification is nearly proportional.

Light Amplifier: Another Step Forward

The direct amplification of light without the use of electronic tubes, a phenomenon sought for by many, was demonstrated recently by scientists from the General Electric Research Lab. in Schenectady, N. Y. While spokesmen from G.E. said that no immediate application should be anticipated, it was mentioned that such a light amplifier may be the clue to the "picture-on-the wall" television screens thought to be possible. Other possible uses are in x-ray fluoroscopy, and photography.

In the demonstration, the scientists increased the brightness of a projected photograph by passing an electric current through a special phosphor cell used as the viewing screen. An ordinary lantern-slide projector was used, and the picture was a regular photo slide. The small screen reflected a yellowish image when an ultra-violet source was used in the projector. But as the voltage on the special screen was increased, the picture became brighter. Neither the light nor the lens was altered.

The demonstration proved one thing—that applying an electric voltage does not of itself cause the special phosphor screen to give off light. Amplification occurs only with the combination of both the voltage and the ultra violet light used in the projector.

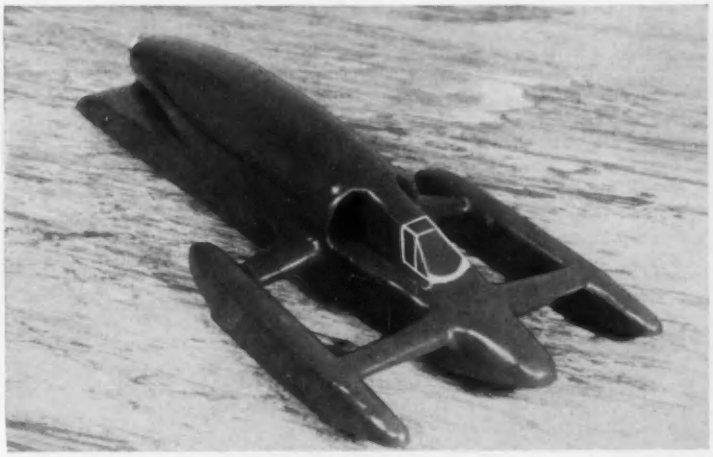
Proof of the true amplication of light is obtained by measuring the number of photons of light striking the screen and comparing this with the number given off. Increases up to ten times have been recorded. G.E. scientists believe that much higher ratios are possible. Because the amount of light reflected is proportional to the light striking the surface, it is possible to brighten the intermediate shades of the projected picture, thus making a brighter picture without washing out the contrast.

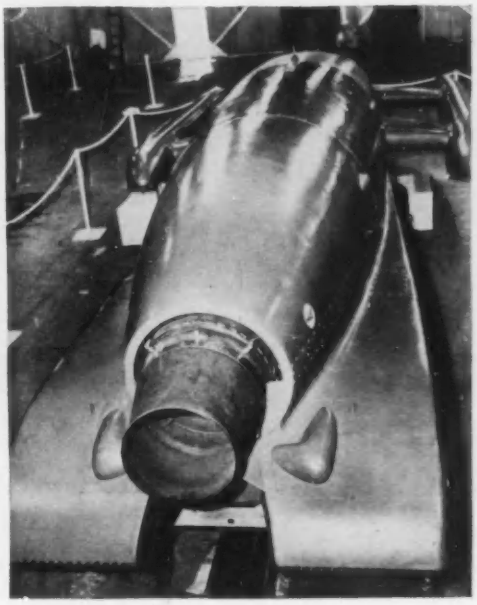
Increased Use of Chemical Nickel-Plating

The commercial application of chemical-nickel plating just received a boost with the opening in Dunkirk, N. Y., of the American Locomotive Co.'s (Alco) new plant. This process is not new, and most of the advances made to date have been by the General American Transportation Corp. (GATX) which now holds most of the patents. GATX developed a method of lining tank cars that would eliminate the disadvantages of the linings being used, and announced the Kanigen process in 1953. (The term Kanigen is derived from the term CAtalytic NIckel GENeration).

Alco has applied the Kanigen process to make their Alcoplate, a chemical-nickel plating of uniform thickness which can be applied to metallic parts of almost any size or shape. Two different continuous flow methods are used: (1) a closed-cycle method for internal coating; (2) immersion process for selective coating both internally and externally of product parts.

The parts to be plated receive sub-





AT RIGHT IS A REAR VIEW of the Bluebird and above a model of the new hydroplane. In it Campbell hopes to beat the water speed record of 178 mph now held by the United States. Designers estimate that when the boat is travelling at speed, it is almost airborne, and that three sections of the hull, each about the size of a man's hand, will be contact with the water. The hydroplane is powered by a turbo-jet engine of 4,000 lb. static thrust.

Breaking the Water Barrier

Passing through the sound barrier was to pilots of jet planes several years ago as breaking the "water barrier" is to present day speedboat enthusiasts. In this jet powered hydroplane called the Bluebird, Donald Campbell, son of the late Sir Malcolm Campbell, hopes to learn more about the strange forces found at the water barrier, which he believes to be about 200 mph. For it was at about this speed that the boats of John Cobb of England, and Verga Marias of Italy disintegrated because of some unknown force.

Mr. Campbell describes this force as "the pressure built up between the water and the planing surfaces of the hull. This results in a high-frequency pitching cycle of great amplitude, the effect of which is to disintegrate the hull structure with an explosive force."

After several years of tests with models in wind tunnels and towing tanks, engineers associated with Campbell designed the first all-metal hydroplane of its kind. The light alloy hull, built around a tubular steel frame, is considered to have twice the strength of the body of a jet fighter. The hull is 24 ft. long, 3 ft. 8 in. wide, and 2 ft. deep, and contains some 275 ft. of chrome-molybdenum seamless tube —mostly 2 in. square section, 14 and 16 gage. The frame alone weighs only 580 pounds; and the boat, including the engine, weighs 2½ tons. The engine is a Vickers-Armstrong Beryl straight turbo-jet unit of 4,000 lb. static thrust.

Because of the lack of scientific knowledge in the field of high-speed water craft, the Bluebird will be replete with instruments, including some new devices for recording the stresses on the hull. Transmitters working on eight different channels will record on television screens on shore the forces acting on the boat. Campbell will be warned by radio if the danger point is approached. Watching too, will be Naval experts who feel that the success of these tests may influence the design of naval craft with speeds of 200 mph.

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stantially the same surface pre-treatment as the parts which are electroplated. The solution of chemicals, at a temperature of 215 F is introduced into the work to be plated. Plating takes place by catalytic reduction of nickel by sodium hypophosphite. From the parts which were plated, the chemical solution passes through flash evaporators and then to the regeneration tanks where concentrated solutions of caustic, nickel sulfate, and sodium hypophosphite are introduced to bring the solution back to its optimum concentration, thus completing the cycle. Alco uses glass pipe and linings for all parts of the system, since the hot plating solution will deposit nickel on almost all material except glass.

Regardless of the size, it takes about the same amount of time to plate any product. Unlike electrolytic plating where the amount of nickel deposited is a result of the current strength, the Alcoplate process plates at a uniform rate—from 0.6 to 1.0 mil per hour, resulting in a chemical composition of 93 percent nickel, and 7 percent phosphorous. Alco is at present depositing 0.003 in. of nickel on converter shells for the AEC.

Other claims by Alco: zero porosity, even in thin plating thicknesses; good adhesion (plated steel showed no flaking or spalling when pulled to the yield point); high hardness (averages about 500 Vickers or 49 Rock. C, and can be increased by post-plating heat treatment to 950 Vickers or 63 Rock. C.); better corrosion resistance than either pure or wrought nickel.

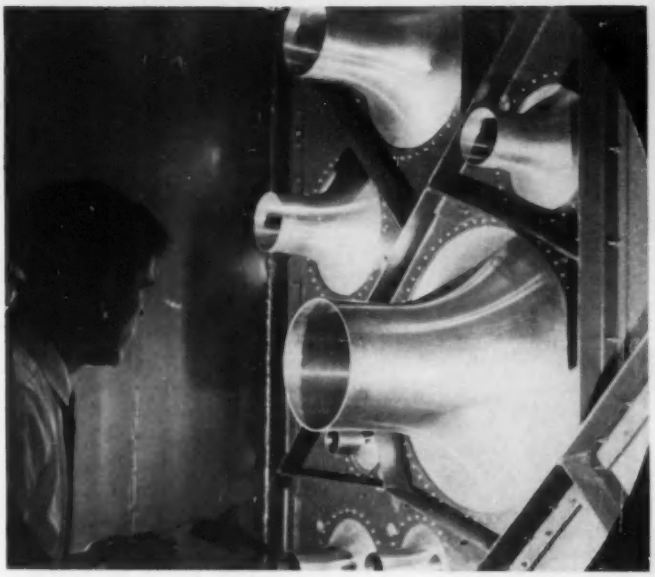
THE NEWS IN PICTURES

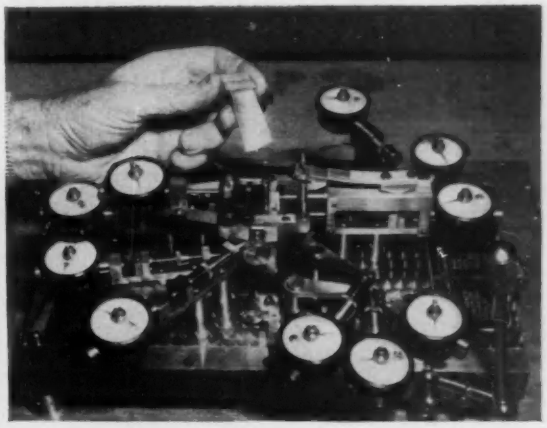
POWERED BY two Pratt & Whitney J-57 turbojet engines developing about 20,000 pounds thrust, McDonnell Aircraft's new F-101A Voodoo is the latest addition to the U. S. Air Force. Wing span is 39.7 ft., with both stabilizer and wings swept back 35 degrees. The wing skin is of heavy, tapered, pre-formed sections. Of interest is the midpoint fuselage bulkhead, which is a carry-through member supporting both engines, and carrying part of the wing load. This piece, which replaces at a savings in cost the 25 parts used in a previous design, was milled from one piece of rolled 75 ST aluminum plate measuring 92 x 55 x 3 in. and weighing 1500 pounds. Final weight of this member is 168 pounds. Fuselage areas adjacent to the exhaust blast are of sheet titanium.

INSTEAD OF PERFORMING their customary decorative duty on Christmas trees, these ornaments are being used by Boeing Airplane Co. to reduce the weight of foamed-plastic fillers for aircraft structures. The ornaments, costing about two dollars a gross wholesale, are dipped in nitric acid to remove their silver coating so they will bond to the plastic. The plastic is poured over the ornaments in a container, and when heated, bubbles up to make foam, which hardens when cured. Before the ornaments, Boeing experimented with hollow aluminum balls, and paper tetrahedrons.

ABOUT THE SIZE OF A DIME, this gyroscope motor has been designed by Westinghouse Electric Corp. for use on the moving antenna of aircraft fire-control radar. This inside-out synchronous motor has a tiny wound stator; the rotor is also the inertia wheel of the gyroscope which measures the angular movement of the antenna. This type of design permits an element with a large polar moment of inertia to be built into a small space. The small 2-phase 400 cycle motor operates on less than a volt per phase, and revolves at 8000 rpm.

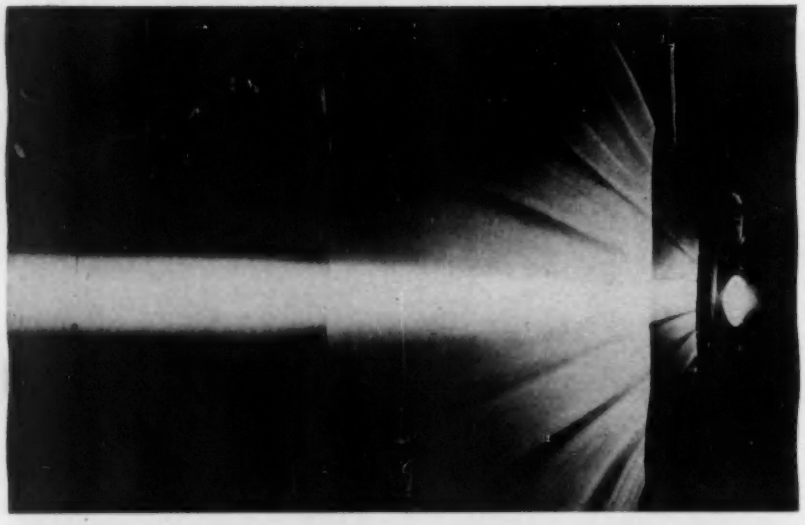
IN A SPECIAL ROOM at General Electric's Locomotive and Car Equipment plant these highly polished, accurately calibrated air nozzles serve as a valve through which air is forced from one-half of the chamber to build up pressure in the other half. The air is then ducted through the motor or generator on test to simulate a range of service conditions, and to find ways of increasing the output of equipment within the design limitations of a locomotive.

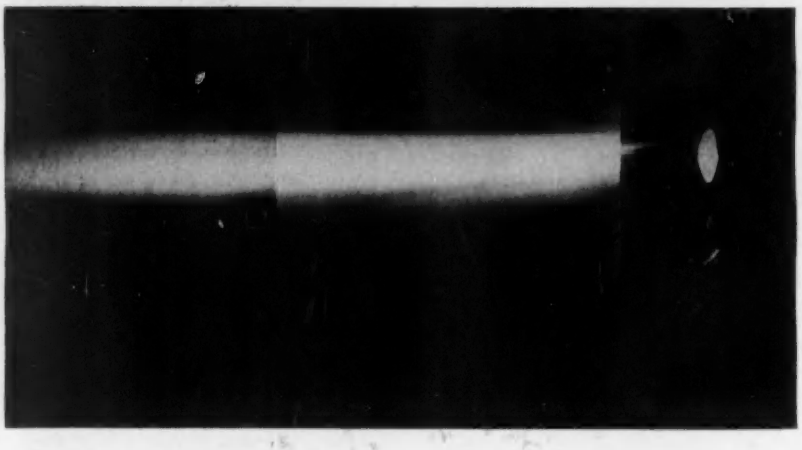




AS MANY AS 150 TURBINE BLADES PER HOUR may be checked by using a new gaging device developed by a tool engineer at Boeing Airplane Co. in Seattle. The checking gages have up to 13 metal "fingers" capable of measuring within 0.0005 inch. These fingers are mounted on springs and extend from the open end of a cylinder. When the finger makes contact with a solid object, it is pushed back into the cylinder, putting pressure against the spring. A linkage connects the other end of the finger to the dial indicator. A perfect master blade is inserted in the device first so that all gages can be set at zero.

THIS DC-7 IS SHOWN RESTING ON SMALL DOLLIES which have just drawn it sideways so that it is flush with entrance to the airline terminal. Designed by Whiting Corp. to speed up airport operations, this Loadair system permits the plane to taxi onto the dollies in their "out" position, with the nose wheel positioned on a single front dollie which can be set on different tracks to accommodate planes of all sizes. After chocks are raised to lock the plane in position, an electrically operated winch pulls the plane in to the platform at the rate of 150 ft. per minute. As the plane approaches the platform, a limit switch contacts the fuselage, and all movement stops. The passenger entrance platform is also adjustable in any direction.





New Headlights For Safer Driving

To make night driving safe and easier, a new type of sealed beam headlamp has been developed which will be adopted as standard equipment by all automobile manufacturers during the 1955 model year. The major improvements are: (1) Better distribution of light on the road, with the low beam giving as much as 80 feet more seeing distance along the right side and shoulder of the road; (2) Reduction of stray light radiating upward from the lower beam filament (see illustration), improving visibility through fog, rain, snow, and dust; (3) More light throughout both beam patterns.

To get the improved light distribution, increased seeing distance, and more light, the low beam has been stepped up from 35 to 40 watts, and the upper beam from 45 to 50 watts. This gives more light ahead of the car, but stays within the statutory limitations on beam candlepower.

The stray upward light from the lower beam has been controlled by an opaque cap positioned over the lower beam filament, and by changes in the lens design.

The new lamps are designed for installation in both six and twelve volt electrical systems, and are interchangeable with older sealed beam units.

The program for improved lights was initiated by the Automobile Manufacturers Association in Sept. 1950, and the new design was approved in October 1953. However, before the new lamps may be installed as original equipment, statutes which govern the type of lighting equipment, must be changed in all states. At present, 22 states must pass this corrective legislation in 1955.

News Briefs

Successful true centrifugal titanium castings, weighing from 3.3 to 9 pounds have been achieved by the Armour Research Foundation of the Illinois Institute of Technology working with the Wisconsin Centrifugal Foundry, Inc. According to Armour metallurgists, melting pure titanium by a new method has prevented contamination from furnace and mold materials, always one of the principal stumbling blocks. Suggested uses for the castings: sealing rings, bushings, and fittings for use in corrosive areas.

Curtiss-Wright Corp. has announced the development of a rocket engine that can be throttled up and down, and which can be started and stopped at will. As yet, there are no details as to its size and power. According to Roy T. Hurley, President, "In the average rocket power plant, the entire fuel supply is burned within a short period of time, and the distance attained at a fixed thrust level depends on the height from which the rocket plane can coast back to earth."

"Every scientist and engineer should be organized in 'minute-men' tradition, with each one assigned to a specific job in time of emergency," according to Prof. Joseph O. Hirshfelder, director of the Univ. of Wisconsin's Naval Research Laboratory. Prof. Hirshfelder believes that every scientist, from the time he is a graduate student, should be given a particular emergency scientific assignment in his specific field of training. Then, in time of war he would report immediately to the research laboratory or other organization. As part of his continuous peacetime training, the scientist would spend two weeks each year working at his war-assignment laboratory. Prof. Hirshfelder claims that while the Defense Dept. has set up elaborate plans for stand-by use of manufacturing facilities, no plan exists for scientists and technologists.

National Engineers' Week will be observed on February 20 to 26, 1955. Remember: The prosperity and safety of our country depend upon the continued ingenuity and application of scientific discoveries to increased productivity and military preparedness.

Coming Events

Feb. 23

The Annual Winter Conference of the New York Section of the Instrument Society of America, at the Hotel Statler, New York. The theme of the Conference will be Scan-N-Log, Instrumentation for Data Reduction and presentation, and the papers presented will cover, in part, some of the newest techniques of analog-to-digital converting, data scanning, and automatic logging.

March 1, 2, 3

The 1955 Joint Western Computer Conference & Exhibit, at the Hotel Statler, Los Angeles, Cal. Sponsored by the IRE, the AIEE, and the Association for Computing Machinery, the theme will be "Functions and Techniques in Analog and Digital Computers." Technical papers and discussions will include descriptions of existing systems and techniques, methods of matching digital tapes and cards, language and communication problems between machines, and new developments in analog computers and computing methods. The exhibit will be limited to the products of manufacturers who make computers or major computer sub-assemblies. Included in the program are evening field trips to major Los Angeles electronic firms. For more information write: William Gunning, Conference Sec., International Tele-metering Conference, 2000 Stoner Ave., Los Angeles 25, Cal.

March 7-11

The 1955 Conference and Exhibition of the National Association of Corrosion Engineers, at the Palmer House, in Chicago, Ill. To date the exhibit will include 127 booths, showing protective coatings, corrosion inhibitors, linings, chemical injectors, anodes, pipe wrapping machines, rectifiers, cathodic protection equipment, plastics, preventive coatings, metal alloys, lead products, and other equipment. Reports will be given on the characteristics of epoxys, chlorinated rubber, rigid vinyls, fluorocarbons, polyesters, furanes and phenolics, vinylidene chloride polymers, and heavy liners. High purity water corrosion data, and data on other subjects will be presented.

March 14-18

The 23rd Annual meeting of the American Society of Tool Engineers, in the Shrine Auditorium and Exposition Hall in Los Angeles, Cal. So far, more than 270 companies are scheduled as exhibitors. General topics for the five days, starting the 14th, are: Professional Developments Day; the 15th, Pressworking Day; the 16th, Management Day; the 17th, Processes Day; the 18th, Precision Control Day. Some session topics will be: "Magnesium Plate for Strong Light-Weight Fixture Construction;" "Industrial Numbering Codes;" "Coding and Administration of Engineering Drawings;" "Gears and Splines;" "Coordination of Manufacturing and Management;" "Heat Treatment of Steels."

March 28—Apr. 1

Ninth Western Metal Exposition, Pan-Pacific Auditorium, and the Ninth Western Metal Congress, Ambassador Hotel, Los Angeles, Cal. Managing sponsor of the show will be the American Society for Metals and 20 other technical societies. ASM sessions will be devoted to the following topics: titanium; powder metals; high-strength steels; die materials and new forming methods for sheet metals; machining and tool materials; and metals used in the petroleum industry. Included are question-answer periods and round table discussions. Further information may be obtained from the Western Metal Exposition headquarters at the Ambassador Hotel, 3400 Wilshire Blvd., Los Angeles 5, Cal.

Apr. 5, 6, 7

The National Fluid Power Association, 1955 Spring (Annual) Meeting at Colorado Springs, Colorado. More information may be obtained from B. N. Ashton, President of the Association, at 1618 Orrington Ave., Evanston, Ill.

Apr. 6

Machine Design Conference at the New York Univ. College of Engineering. Theme: "Product Consideration in Machine Design." Co-sponsors are the Machine Design Div., and the Metropolitan Section of ASME. Titles of the form papers to be presented have not been received, but the topics will be materials selection, surface finish, and fabrication methods. Contact Richard Magat at NYU, College of Engineering, University Heights, 181st St. and University Ave., Bronx, N. Y.

Apr. 6-10

World Plastics Fair & Trade Exposition, Los Angeles, Cal. Tools, machinery, and equipment used in the field of plastics, as well as new materials and material applications will be shown. Exhibits will be of interest to processors, laminators, extruders, molders, vacuum formers, as well as large plastic using industries such as aircraft, electronics, petroleum, construction, and others. Copies of the fact sheet on the fair may be obtained from: World Plastics Fair & Trade Exposition Management, 8762 Holloway Drive, Los Angeles 46, Cal.

Apr. 13, 14, 15

American Society of Lubrication Engineers, the 10th Annual Meeting and Lubrication Exhibit, at the Hotel Sherman, Chicago, Ill. Forty-one papers have already been tentatively scheduled in 16 sessions. Five of these sessions will be devoted exclusively to a special short course in lubrication engineering during the meeting. One panel will cover "Controls for Extending the Useful Life of Coolants while in Use." One symposium, to be held in two sections, will discuss "Fundamentals of Wear," and will cover the latest theories and developments in this field. Other sessions will cover: film type bearings; properties of lubricants; present thinking in gear lubrication; lubricant dispensing; equipment application; rolling contact bearings; organization of a plant lubrication program; hydraulics; and several others.

Apr. 27-29

Society for Experimental Stress Analysis, Spring Meeting, Hotel Statler, Los Angeles, Cal. For more information, write to: Dr. W. M. Murray, Sec.-Treasurer of the Society, P. O. Box 168, Central Square Station, Cambridge 39, Mass.

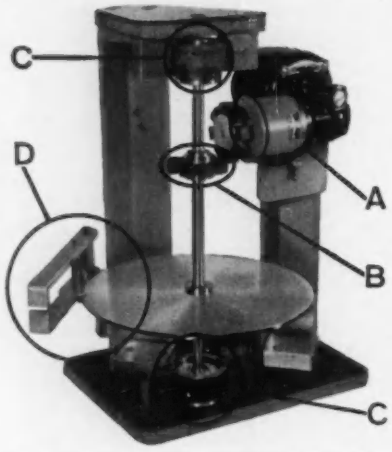
(*Advertisement*)

Carboloy Trends and Developments for Design Engineers:

How to simplify design with permanent magnets
How to slow down wear with cemented carbides

Model demonstrates permanent-magnet functions

Even to design engineers, permanent magnets are often a puzzle. But most engineers do know that permanent magnets can simplify design and improve their products – reduce size and cost, too. To demonstrate some of the basic functions of permanent magnets, Carboloy magnet engineers developed this working model. (See it at our Booth 530, IRE Show, New York, March 21-24.) Here's what it demonstrates.



Magnetic control of torque. The adjustable, frictionless hysteresis brake (A), which transmits torque to turn the vertical 8-pole magnet, is an example of how Carboloy® permanent magnets can *convert mechanical motion to thermal energy.* Here, as in the following applications, there is no physical contact between the magnets and the component being controlled.

Magnetic driving. The vertical magnet drives the horizontal 8-pole magnet (B) at the same speed transmitted by the hysteresis brake . . . another use of the principle of converting mechanical motion to thermal energy.

Magnetic suspension. The aluminum disc and shaft assembly is suspended and held in position by two pairs of concentric, ring-type Carboloy magnets (C), located at the top and bottom of the shaft. This *mechanical holding principle* is also used for snap action, separation, and lifting.

Magnetic braking. Utilizing eddy current effect, the brake assembly (D) establishes magnetic fields of opposed polarity to the field of the braking mechanism . . . thus, when pivoted into position, it controls the speed of the disc and shaft. The eddy current effect – like instrument action, motor action, acoustic action, and electron beam control – is derived from permanent magnets' ability to *convert electrical energy to mechanical motion.*

In addition, permanent magnets can also *convert mechanical motion to electrical energy* (generator action, magneto action, sound pickup). Our magnet engineers can give you technical assistance in the design and application of Carboloy permanent magnets. Write for Magnet Design Manual PM-101 and Technical Data Sheet PM-116.

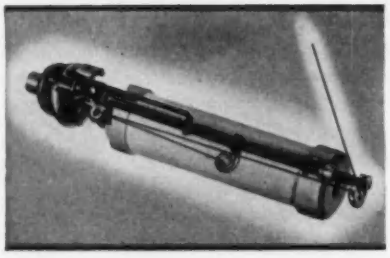
Cemented carbides are an engineering material

To those who think of cemented carbides as exclusively a material for dies and cutting tools, this will be news: *Design engineers* are finding thousands of uses for cemented carbides as an *engineering material.* That's because where friction, erosion, corrosion or abrasion occur, carbides outlast steel from 10 to 50 times . . . and in some cases even outlast the machine they are protecting.

Carbides are the hardest metals made by man – second only to the diamond in hardness. With their high hardness, they combine many other physical properties important to the designer: high transverse rupture strength, high compressive strength, high modulus of elasticity.

Carboloy cemented carbides are made in a wide range of grades . . . hence, almost any combination of physical properties can be produced. Standard grades are stocked in a variety of sizes and shapes; and any combination of grade, size and shape can be made to fit particular design requirements.

Here are some of the many applications where designers are utilizing carbides' unique properties to reduce sharply America's annual multimillion-dollar wear bill: sandblast nozzles, paper-slitting knives, textile guides (shown above), powder metallurgy dies, petroleum balls and seats, tabulating machine wear parts, ceramic molds, gages, pulverizer blades and fishing reel bearings.



These are just samples of the wear problems our engineers have solved. Let us help you with your design problems involving wear. And we can also assist with designing into your product our other Created-Metals: Hevimet (for high density and radioactive shielding uses), Thermistors (for minute temperature control), and vacuum-melted metals.

"Carboloy" is the trademark for products of the Carboloy Department of General Electric Company

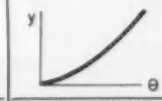
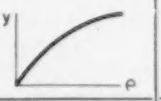
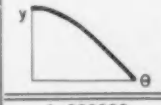
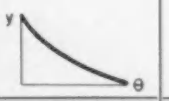
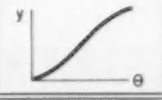
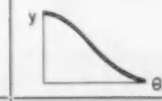
CARBOLOY
DEPARTMENT OF GENERAL ELECTRIC COMPANY

11127 E. 8 Mile Ave., Detroit 32, Michigan

CARBOLOY CREATED-METALS FOR INDUSTRIAL PROGRESS

Plate Cam Tables (continued from page 162)

Table II—Cycloidal Motion Displacement Factors

θ	DISPLACEMENT (y)					
	C_1 	C_2 	C_3 	C_4 	C_5 	C_6 
0	0.000000	0.000000	1.000000	1.000000	0.000000	1.000000
1	0.000008	0.033326	0.999992	0.966674	0.000030	0.999970
2	0.000061	0.066606	0.999939	0.933394	0.000243	0.999757
3	0.000205	0.099795	0.999795	0.900205	0.000818	0.999182
4	0.000486	0.132847	0.999514	0.867153	0.001933	0.998067
5	0.000949	0.165718	0.999051	0.834282	0.003756	0.996244
6	0.001637	0.198363	0.998363	0.801637	0.006451	0.993549
7	0.002595	0.230739	0.997405	0.769261	0.010171	0.989829
8	0.003865	0.262802	0.996135	0.737198	0.015058	0.984942
9	0.005490	0.294510	0.994510	0.705490	0.021241	0.978759
10	0.007512	0.325822	0.992488	0.674178	0.028834	0.971166
11	0.009969	0.356697	0.990031	0.643303	0.037938	0.962062
12	0.012902	0.387098	0.987098	0.612902	0.048635	0.951365
13	0.016348	0.416986	0.983652	0.583014	0.060990	0.939010
14	0.020342	0.446324	0.979658	0.553676	0.075050	0.924950
15	0.024921	0.475079	0.975079	0.524921	0.090845	0.909155
16	0.030116	0.503217	0.969884	0.496783	0.108384	0.891616
17	0.035960	0.530707	0.964040	0.469293	0.127656	0.872344
18	0.042482	0.557518	0.957518	0.442482	0.148635	0.851365
19	0.049710	0.583624	0.950291	0.416376	0.171271	0.828729
20	0.057669	0.608998	0.942331	0.391002	0.195501	0.804499
21	0.066384	0.633616	0.933616	0.366384	0.221241	0.778759
22	0.075876	0.657457	0.924124	0.342543	0.248391	0.751609
23	0.086165	0.680501	0.913835	0.319499	0.276838	0.723162
24	0.097269	0.702731	0.902731	0.297269	0.306451	0.693549
25	0.109203	0.724130	0.890797	0.275870	0.337089	0.662911
26	0.121979	0.744687	0.878021	0.255313	0.368599	0.631401
27	0.135609	0.764391	0.864391	0.235609	0.400818	0.599182
28	0.150101	0.783233	0.849900	0.216767	0.433576	0.566423
29	0.165460	0.801207	0.834540	0.198793	0.466697	0.533303
30	0.181690	0.818310	0.818310	0.181690	0.500000	0.500000
31	0.198793	0.834540	0.801207	0.165460	0.533303	0.466697
32	0.216767	0.849900	0.783233	0.150101	0.566423	0.433576
33	0.235609	0.864391	0.764391	0.135609	0.599182	0.400818
34	0.255313	0.878021	0.744687	0.121979	0.631401	0.368599
35	0.275870	0.890797	0.724130	0.109203	0.662911	0.337089
36	0.297269	0.902731	0.702731	0.097269	0.693549	0.306451
37	0.319499	0.913835	0.680501	0.086165	0.723162	0.276838
38	0.342543	0.924124	0.657457	0.075876	0.751609	0.248391
39	0.366384	0.933616	0.633616	0.066384	0.778759	0.221241
40	0.391002	0.942331	0.608998	0.057669	0.804499	0.195501
41	0.416376	0.950291	0.583624	0.049710	0.828729	0.171271
42	0.442482	0.957518	0.557518	0.042482	0.851365	0.148635
43	0.469293	0.964040	0.530707	0.035960	0.872344	0.127656
44	0.496783	0.969884	0.503217	0.030116	0.891616	0.108384
45	0.524921	0.975079	0.475079	0.024921	0.909155	0.090845
46	0.553676	0.979658	0.446324	0.020342	0.924950	0.075050
47	0.583014	0.983652	0.416986	0.016348	0.939010	0.060990
48	0.612902	0.987098	0.387098	0.012902	0.951365	0.048635
49	0.643303	0.990031	0.356697	0.009969	0.962062	0.037938
50	0.674178	0.992488	0.325822	0.007512	0.971166	0.028834
51	0.705490	0.994510	0.294510	0.005490	0.978759	0.021241
52	0.737198	0.996135	0.262802	0.003865	0.984942	0.015058
53	0.769261	0.997405	0.230739	0.002595	0.989829	0.010171
54	0.801637	0.998363	0.198363	0.001637	0.993549	0.006451
55	0.834282	0.999051	0.165718	0.000949	0.996244	0.003756
56	0.867153	0.999514	0.132847	0.000486	0.998067	0.001933
57	0.900205	0.999795	0.099795	0.000205	0.999182	0.000818
58	0.933394	0.999939	0.066606	0.000061	0.999757	0.000243
59	0.966674	0.999992	0.033326	0.000008	0.999970	0.000030
60	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

(continued on page 213)

JOIN NATIONAL LEADERS WHO USE T and W DEEP DRAWN STAMPINGS
★ ★ ★ ★ ★ ★ ★ Such prominent firms manufacture fine products . . . and require well-made component parts. You, too, can be sure of quality deep drawn stampings when you specify
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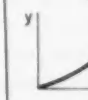
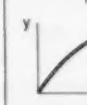
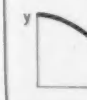
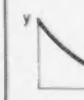
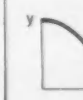
PRODUCT ENGINEERING - REFERENCE BOOK SHEET

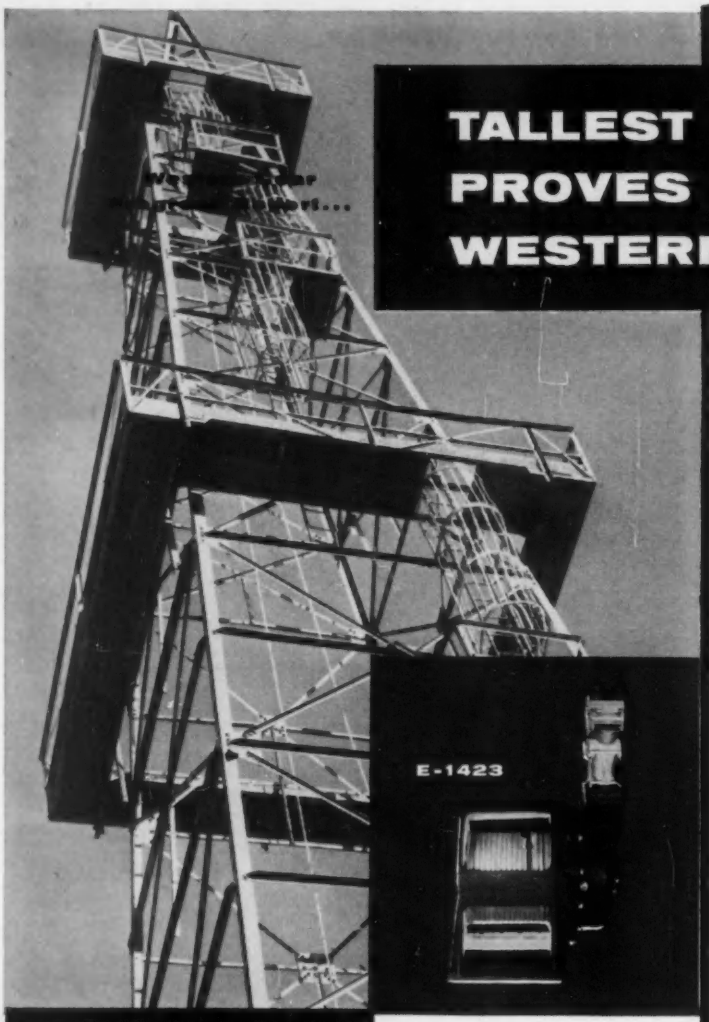
Plate Cam Tables (continued from page 211)

Table III—Harmonic Motion Displacement Factors

θ	DISPLACEMENT (y)					
	H_1 	H_2 	H_3 	H_4 	H_5	H_6 
0	0.000000	0.000000	1.000000	1.000000	0.000000	1.000000
1	0.000343	0.026177	0.999657	0.973824	0.000685	0.999315
2	0.001371	0.052336	0.998630	0.947665	0.002739	0.997261
3	0.003083	0.078459	0.996917	0.921542	0.006156	0.993844
4	0.005478	0.104528	0.994522	0.895472	0.010926	0.989074
5	0.008555	0.130526	0.991445	0.869475	0.017037	0.982963
6	0.012312	0.156434	0.987688	0.843565	0.024472	0.975528
7	0.016745	0.182236	0.983255	0.817765	0.033210	0.966790
8	0.021852	0.207912	0.978148	0.792089	0.043227	0.956773
9	0.027630	0.233445	0.972370	0.766555	0.054497	0.945503
10	0.034074	0.258819	0.965926	0.741181	0.066987	0.933013
11	0.041180	0.284015	0.958820	0.715985	0.080665	0.919335
12	0.048944	0.309017	0.951057	0.690983	0.095492	0.904509
13	0.057359	0.333807	0.942641	0.666193	0.111427	0.888573
14	0.066420	0.358368	0.933580	0.641632	0.128428	0.871572
15	0.076121	0.382683	0.923880	0.617317	0.146447	0.853554
16	0.086455	0.406737	0.913546	0.593264	0.165435	0.834565
17	0.097415	0.430511	0.902585	0.569489	0.185340	0.814660
18	0.108994	0.453991	0.891007	0.546010	0.206107	0.793893
19	0.121183	0.477159	0.878817	0.522841	0.227680	0.772320
20	0.133975	0.500000	0.866025	0.500000	0.250000	0.750000
21	0.147360	0.522499	0.852640	0.477501	0.273005	0.726995
22	0.161329	0.544639	0.838671	0.455361	0.296632	0.703368
23	0.175874	0.566406	0.824126	0.433594	0.320816	0.679184
24	0.190983	0.587785	0.809017	0.412215	0.345491	0.654509
25	0.206647	0.608761	0.793353	0.391239	0.370590	0.629410
26	0.222854	0.629320	0.777146	0.370680	0.396044	0.603956
27	0.239594	0.649448	0.760406	0.350552	0.421783	0.578217
28	0.256855	0.669131	0.743145	0.330869	0.447736	0.552264
29	0.274626	0.688355	0.725374	0.311645	0.473832	0.526168
30	0.292893	0.707107	0.707107	0.292893	0.500000	0.500000
31	0.311645	0.725374	0.688355	0.274626	0.526168	0.473832
32	0.330869	0.743145	0.669131	0.256855	0.552264	0.447736
33	0.350552	0.760406	0.649448	0.239594	0.578217	0.421783
34	0.370680	0.777146	0.629320	0.222854	0.603956	0.396044
35	0.391239	0.793353	0.608761	0.206647	0.629410	0.370590
36	0.412215	0.809017	0.587785	0.190983	0.654509	0.345491
37	0.433594	0.824126	0.566406	0.175874	0.679184	0.320816
38	0.455361	0.838671	0.544639	0.161329	0.703368	0.296632
39	0.477501	0.852640	0.522499	0.147360	0.726995	0.273005
40	0.500000	0.866025	0.500000	0.133975	0.750000	0.250000
41	0.522841	0.878817	0.477159	0.121183	0.772320	0.227680
42	0.546010	0.891007	0.453991	0.108994	0.793893	0.206107
43	0.569489	0.902585	0.430511	0.097415	0.814660	0.185340
44	0.593264	0.913546	0.406737	0.086455	0.834565	0.165435
45	0.617317	0.923880	0.382683	0.076121	0.853554	0.146447
46	0.641632	0.933580	0.358368	0.066420	0.871572	0.128428
47	0.666193	0.942641	0.333807	0.057359	0.888573	0.111427
48	0.690983	0.951057	0.309017	0.048944	0.904509	0.095492
49	0.715985	0.958820	0.284015	0.041180	0.919335	0.080665
50	0.741181	0.965926	0.258819	0.034074	0.933013	0.066987
51	0.766555	0.972370	0.233445	0.027630	0.945503	0.054497
52	0.792089	0.978148	0.207912	0.021852	0.956773	0.043227
53	0.817765	0.983255	0.182236	0.016745	0.966790	0.033210
54	0.843565	0.987688	0.156434	0.012312	0.975528	0.024472
55	0.869475	0.991445	0.130526	0.008555	0.982963	0.017037
56	0.895472	0.994522	0.104528	0.005478	0.989074	0.010926
57	0.921542	0.996917	0.078459	0.003083	0.993844	0.006156
58	0.947665	0.998630	0.052336	0.001371	0.997261	0.002739
59	0.973824	0.999657	0.026177	0.000343	0.999315	0.000685
60	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

(continued on page 215)

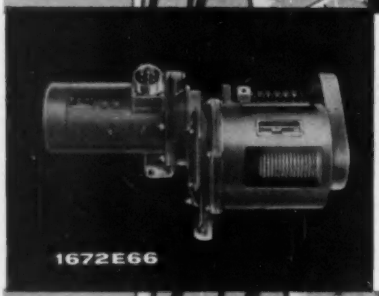
TALLEST TEST STAND PROVES RELIABILITY OF WESTERN GEAR HOISTS

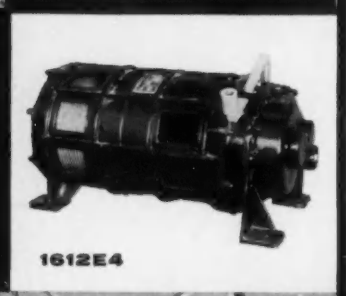


One of the world's tallest hoist test stands, this 120′ tower erected at the Lynwood plant of Western Gear Works provides exact duplication of the dynamic conditions experienced on a cable at full length and on hoist mechanisms when raising and lowering specified loads. It also enables Western Gear engineers to study the regenerative motor characteristics involved during lowering. Data thus obtained provides positive information on cable up to 120′ in length, motive power and hoist mechanism itself.

It's another example of Western Gear thoroughness which characterizes all its products.

Western Gear has been designing and building hoists and other specialized equipment for transmitting motion or torque for virtually every industrial application. Why not take advantage of this experience and skill in solving your mechanical power transmission problems? No obligation! Address inquiries to Executive Offices, Western Gear Works, P.O. Box 182, Lynwood, California.

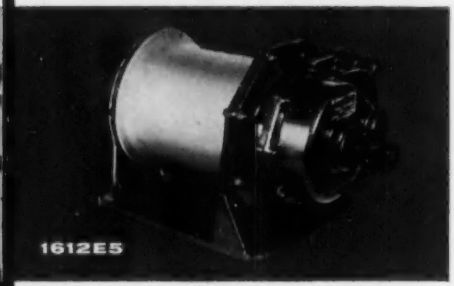




MODEL E-1423 CABLE DRUM: Spooling capacity, 20′ of ¼" cable. Maximum cable pull 6500 lbs. Unlimited travel. Speed 8 RPM. Powered by hydraulic motor. Direction, reversible.

MODEL 1612E4 HOIST: Has 50′ of active cable drum capacity. 55′ of 3/16" diameter cable. Operating load up to 1600 lbs. Capable of operating 30 FPM. Incorporates unique feature of paying cable off at a fixed point. Powered by a low pressure air motor with hand crank for emergency operation.

MODEL 1672E66 HOIST: Spools 150′ of 3/16" cable; 800 lbs. operating load. 50 FPM average cable speed. Maximum lift of 1200 lbs. Ultimate static load 3,000 lbs. Cable level wind device furnished. Unit powered by 28 V. DC motor.



MODEL 1612E5 CAPSTAN: For use with rope. Has operating load of 1600 lbs. at rate of 30 feet per minute. Powered by low pressure air motor.

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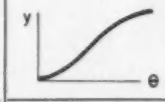
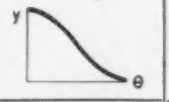
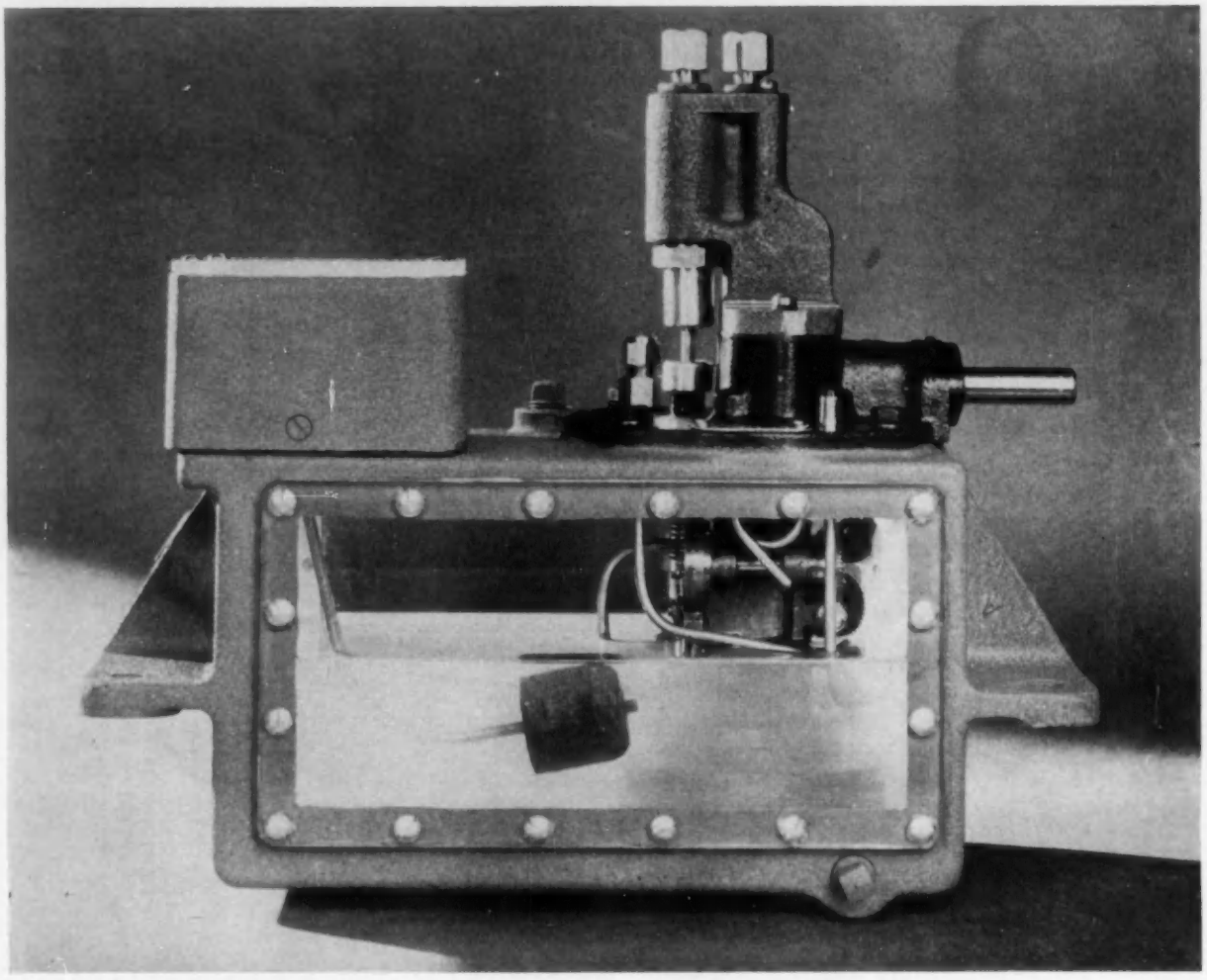
PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.) SEATTLE AND HOUSTON—REPRESENTATIVES IN PRINCIPAL CITIES

Plate Cam Tables (continued from page 213)

Table IV—Eighth Power Polynomial Motion Displacement Factors

θ	DISPLACEMENT (y)		
	P_1 	P_2 	P_3
0	0.000000	1.000000	0.000000
1	0.000028	0.999268	0.000225
2	0.000225	0.997074	0.001782
3	0.000756	0.993415	0.005915
4	0.001782	0.988295	0.013718
5	0.003454	0.981719	0.026083
6	0.005915	0.973688	0.043674
7	0.009297	0.964213	0.066913
8	0.013718	0.953301	0.095979
9	0.019283	0.940967	0.130816
10	0.026083	0.927232	0.171155
11	0.034193	0.912115	0.216533
12	0.043674	0.895645	0.266325
13	0.054571	0.877855	0.319774
14	0.066913	0.858784	0.376027
15	0.080716	0.838475	0.434165
16	0.095979	0.816978	0.493238
17	0.112688	0.794352	0.552294
18	0.130816	0.770658	0.610405
19	0.150323	0.745967	0.666695
20	0.171155	0.720354	0.720354
21	0.193250	0.693901	0.770658
22	0.216533	0.666695	0.816978
23	0.240922	0.638830	0.858784
24	0.266325	0.610405	0.895645
25	0.292643	0.581524	0.927232
26	0.319774	0.552294	0.953301
27	0.347606	0.522827	0.973688
28	0.376027	0.493238	0.988295
29	0.404919	0.463645	0.997074
30	0.434165	0.434165	1.000000
31	0.463645	0.404919	0.997074
32	0.493238	0.376027	0.988295
33	0.522827	0.347606	0.973688
34	0.552294	0.319774	0.953301
35	0.581524	0.292643	0.927232
36	0.610405	0.266325	0.895645
37	0.638830	0.240922	0.858784
38	0.666695	0.216533	0.816978
39	0.693901	0.193250	0.770658
40	0.720354	0.171155	0.720354
41	0.745967	0.150323	0.666695
42	0.770658	0.130816	0.610405
43	0.794352	0.112688	0.552294
44	0.816978	0.095979	0.493238
45	0.838475	0.080716	0.434165
46	0.858784	0.066913	0.376027
47	0.877855	0.054571	0.319774
48	0.895645	0.043674	0.266325
49	0.912115	0.034193	0.216533
50	0.927232	0.026083	0.171155
51	0.940967	0.019283	0.130816
52	0.953301	0.013718	0.095979
53	0.964213	0.009297	0.066913
54	0.973688	0.005915	0.043674
55	0.981719	0.003454	0.026083
56	0.988295	0.001782	0.013718
57	0.993415	0.000756	0.005915
58	0.997074	0.000225	0.001782
59	0.999268	0.000028	0.000225
60	1.000000	0.000000	0.000000



GLASS PLATE PERMITS interior view of lubricating device that automatically provides continuous, spray and jet application of oil to a bottling machine's gears, followers, bearings, cylinders, cam and chain.

Automatic Continuous, Jet and Spray Lubrication

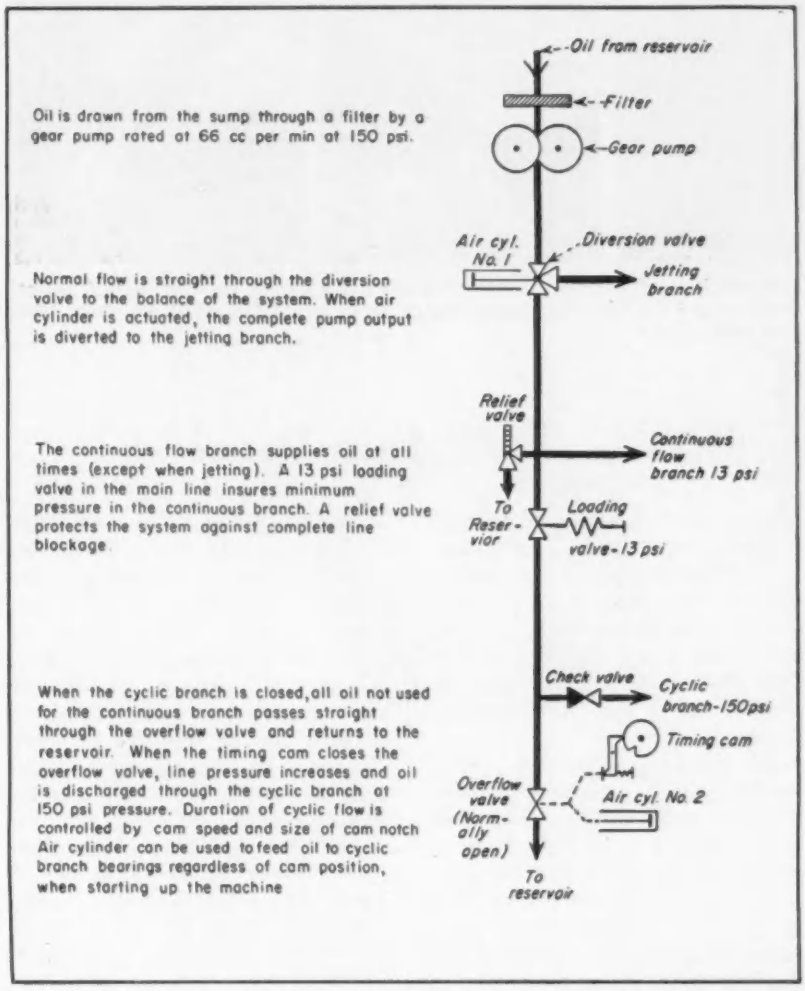
A line of lubricators has been developed for machines which require several methods of automatic lubrication from a single source. Originally designed for bottling machines of the Crown Cork & Seal Co., these lubricators can be adapted for other machines whose construction requires several simultaneous, yet different, oiling techinques.

Several types of Crown Cork & Seal machines now use these triple-service lubricators as standard equipment, with various manual, pneumatic or automatic operating modifications. The lubricator shown is equipped with pneumatic control. It provides three lubricating services: continuous, cyclic and jetting lubrication.

The continuous branch lubricates a pair of gears, a cam and 30 followers; the cyclic branch lubricates a series of bearings, a chain and several gears; the jetting branch sprays oil on 30 lift cylinders.

The continuous branch operates at low pressure, controlled by a loading valve located between the by-pass and the main gear pump discharge. The oil is forced through tubing to the various points where it is distributed through metering units according to the individual needs of each bearing surface.

The cyclic branch operates at high pressure on a predetermined time schedule. A cam, driven by the internal reduction gearing, actuates a timing valve every 18 min when the


Oil is drawn from the sump through a filter by a gear pump rated at 66 cc per min at 150 psi.
Normal flow is straight through the diversion valve to the balance of the system. When air cylinder is actuated, the complete pump output is diverted to the jetting branch.
The continuous flow branch supplies oil at all times (except when jetting). A 13 psi loading valve in the main line insures minimum pressure in the continuous branch. A relief valve protects the system against complete line blockage.
When the cyclic branch is closed, all oil not used for the continuous branch passes straight through the overflow valve and returns to the reservoir. When the timing cam closes the overflow valve, line pressure increases and oil is discharged through the cyclic branch at 150 psi pressure. Duration of cyclic flow is controlled by cam speed and size of cam notch. Air cylinder can be used to feed oil to cyclic branch bearings regardless of cam position, when starting up the machine
Oil from reservoir
Filter
Gear pump
Air cyl. No. 1
Diversion valve
Jetting branch
Relief valve
Continuous flow branch 13 psi
To Reservoir
Loading valve-13 psi
Check valve
Cyclic branch-150psi
Timing cam
Overflow valve (Normally open)
Air cyl. No. 2
To reservoir

FLOW OF OIL through lubricating device's pump, valves and individual distributing lines is shown schematically.

machine is operating in the intermediate speed range. Oil is forced into the proper tubing for the cyclic system. Here, too, metering units at each outlet point in this system insure proper oil distribution.

Jetting is accomplished by operation of a piston valve in the pump which permits oil to discharge through ports to the jetting line. This valve is actuated by a pneumatic cylinder which is in turn operated through a solenoid air valve controlled either by a timer or a push button on the machine control panel. When the pneumatic cylinder is actuated, oil is forced through the jetting line to two nozzles which spray the oil on to the bottle lift cylinders as they rotate.

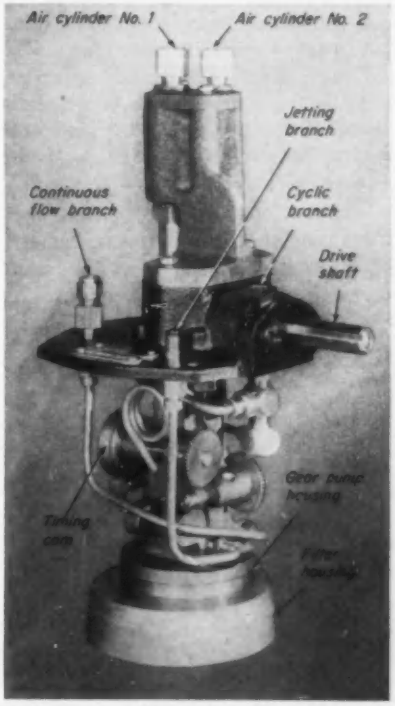
A second pneumatic cylinder provides instant feed control for the cyclic and continuous flow branches, regardless of cam position. This control, usually operated when the machine is started, assures immediate lubrication for all bearings.

The Type AJD lubricating unit is basically a gear pump with a delivery control and timing device suspended from the cover plate. The mechanism is driven from the lubricator shaft. Constant rotation of this shaft causes the gear pump to draw oil through a filter and deliver it to a valve chamber where a cam-actuated valve controls the high and continuous pressure systems. Oil delivery to the high pressure branch is at predetermined intervals, while delivery to the continuous lubricating line is uninterrupted and at low pressure.

This automatic lubricator includes a float switch which first flashes a warning light when the oil level in the reservoir reaches the refilling stage, and then shuts down the machine when the oil reaches the minimum safe level. The machine cannot be re-started until the oil supply has been replenished.

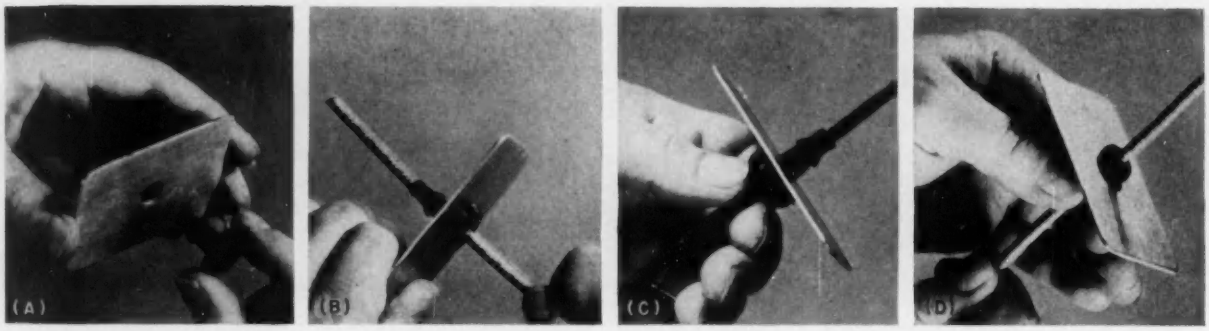
All types of flow are provided by one gear pump, driven by reduction gearing. Bijur Lubricating Corp., Rochelle Park, N. J.

For more information—
Circle 1, inside back cover



PUMPING AND METERING UNIT is shown alone, outside of its reservoir and without float switch. It measures 9¼ in. in height.

CONTINUED ON PAGE 218



(A) Hold the grommet by its head. Insert it in the hole. (B) Push the wire through the grommet head, at least 6 inches. (C) Place the thumb and first finger of one hand around the wire, just behind the grommet head. (D) With the other hand pull the wire quickly and steadily until the grommet locks.

Locks Wire, Rod or Tube Into Panel

A recently introduced grommet will lock a wire, rod or tube into the housing of an electrical device, the firewall of an automobile, the instrument panel of an airplane or any similar member. It serves a secondary purpose as a seal.

Specific types of these grommets have held hydrostatic pressures of 225 psi. Sealing can be against water, air, gases, moisture, chemicals, oils, solvents, dust. Outboard or overhung loads, such as lamps or switches or small assemblies of any kind are said to be readily supported by these grommets.

The motions needed for assembling the grommet with its support, can be so controlled as to bring the supported device into precise position in relation to its housing or to other members with which it must function. Disassembly of the unit in which the grommet is a component can be accomplished easily. Or with a different design of the grommet, such disassembly can be made impossible unless the grommet is destroyed.

All grommets of this type are inherently shock absorbing, vibration damping and silencing. This property is subject to a high degree of control in accordance with the grommet design and the material of which the grommet is made. With appropriate changes in the grommet design, the hole in the suporting member of the assembly can be clean, flanged, extruded or recessed.

The new grommets also can serve as shock mounts or "feet" for instruments, electric motors, portable machines, adding machines, typewriters, motion picture projectors. When so used, they reduce noise, and prevent scratching of desk or table tops.

There are no standard or stock numbers; all designs are special. They range from 0.090 in. bore for television wiring, to 2¼ in. bore for air conditioning systems. But there are no known limitations on the dimensions to which these new locking grommets can be made. Spencer Rubber Products Company, Manchester, Connecticut.

For more information—
Circle 2, inside back cover

Etching Process Produces Intricate Metal Stampings

A quick, relatively inexpensive way of producing sheet metal stampings by a chemical etching process has been developed by Chance Vought Aircraft, Inc., Dallas, Tex., as a substitute for the conventional metal removal methods of drilling, routing, and blanking or piercing. In principle like the technique used by photo engravers, the company makes sheet metal stampings without the aid of mechanical dies and eliminates setup costs ordinarily involved in mechanical metal removal methods.

With this process, metal parts can be made by first creating a black and white master drawing in any scale that will give complete details of the part. This drawing is then transferred to the desired metal by photo engraving, metal lithographing or silk screen printing, using a specially developed resisting ink or compound.

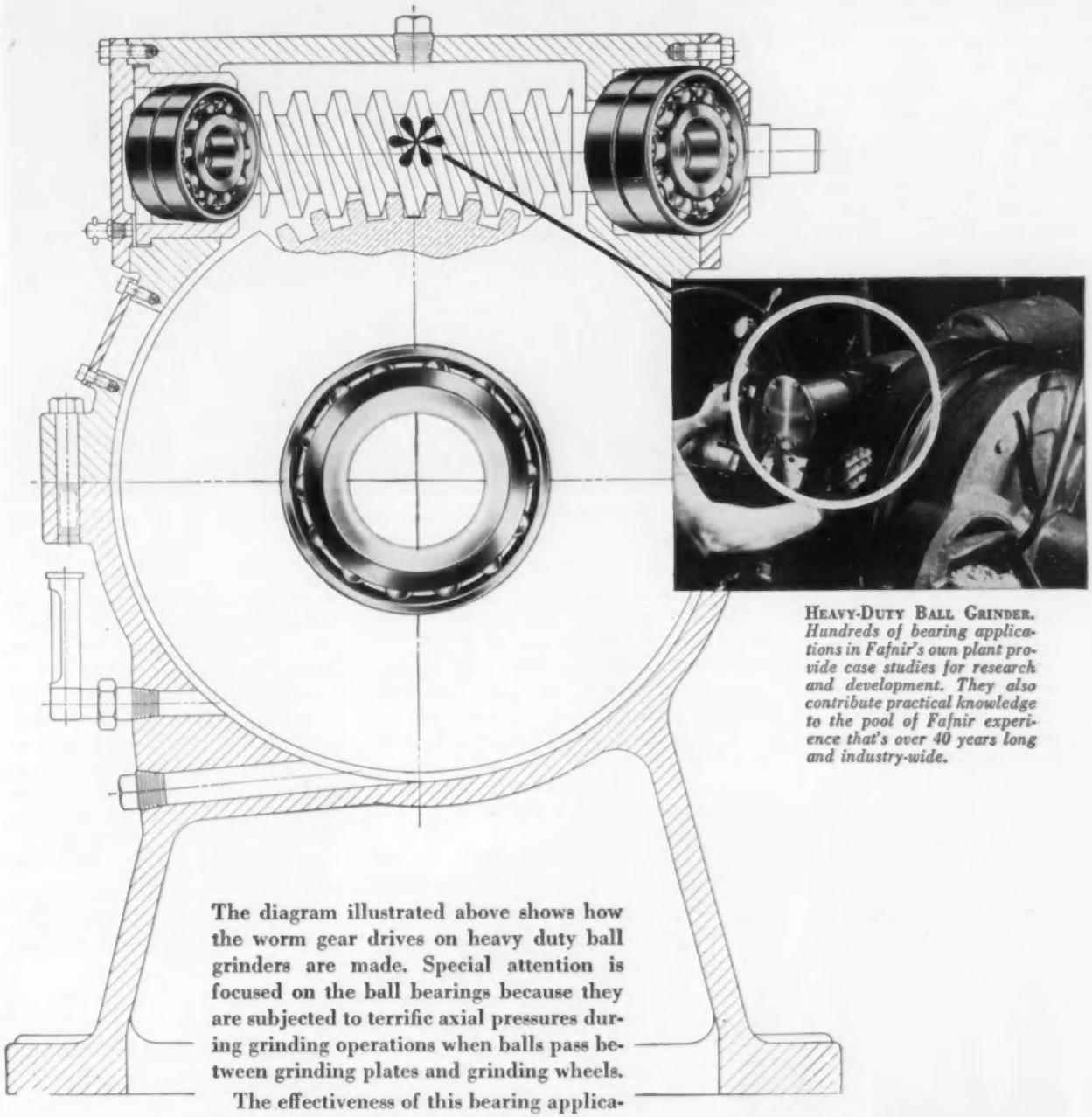
The unwanted material not covered by the acid resist is then etched away, using suitable chemicals, and the remaining metal becomes the desired part. This process is particularly valuable in making large numbers of intricate parts of odd shapes.

One operation in which the new metal-working process proved useful was as a substitute for welded screen asemblies. In this instance, a power plant generator air screen as originally designed consisted of a frame

CONTINUED ON PAGE 220

More Turns For The Worm

on Fafnir Ball Bearings



HEAVY-DUTY BALL GRINDER. *Hundreds of bearing applications in Fafnir's own plant provide case studies for research and development. They also contribute practical knowledge to the pool of Fafnir experience that's over 40 years long and industry-wide.*

The diagram illustrated above shows how the worm gear drives on heavy duty ball grinders are made. Special attention is focused on the ball bearings because they are subjected to terrific axial pressures during grinding operations when balls pass between grinding plates and grinding wheels.

The effectiveness of this bearing application is a matter of record. On the worm gear shaft illustrated, the duplex pairs of bearings have been in operation for 16 years without replacement . . . protecting the worm gear by rigidly locating its shaft and affording adequate carrying capacity for the combined radial and heavy thrust loads.

If you have similar equipment, maybe we can help extend its service life. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

and six welded screens of which each individual wire strand had to be spot welded. In some cases these strands came loose and presented a definite hazard of eventually entering the engine. This existing assembly had 216 spot welds.

Type 302 stainless steel strip was used instead, with all screening integral, all holes cut out, and even the part shape cut out in the one etching operation. This strip required no burring. Time from making the drawing to the first finished part was less than 3 hr.

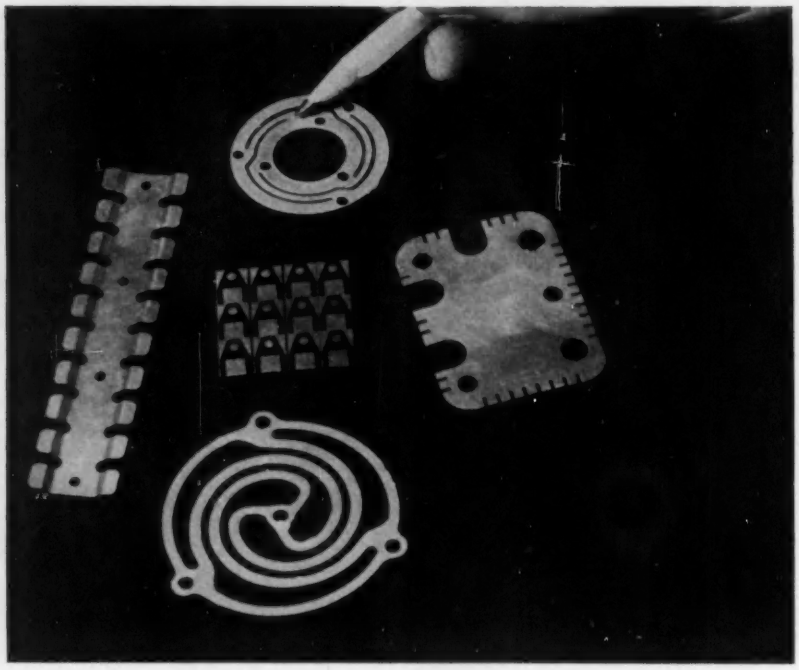
Cost studies have indicated that with many applications of this new method; savings up to 80 per cent per part can be realized.

Other applications of the process, which has wide manufacturing possibilities, included making stencils for making electronic chassis and various other parts out of 0.005 in. brass shim stock. Stencils made by this method are relatively inexpensive, durable marking devices, and are much more economical than paper or metal decals and neater than hand lettering.

Chance Vought needed a copper wire circuit laminated between layers of glass cloth. Made by the conventional method, the cloth had a protrusion on its exterior due to the diameter of the wire.

The problem was to reduce the cross sectional area of the wire without decreasing the current carrying capacity. The circuit was etched from flat copper sheet stock, bonded to a 0.003 in. soft glass fiber cloth that would conform to any contour and then laminated between layers of glass fiber. This resulted in reduction of wire diameter from 0.016 to 0.005 in. and eliminated the protrusions.

NEW AND OLD WAYS of producing unit having a screen component. Spot welding was almost eliminated in the rear screen, made by etching at solid piece of metal sheet.



ELECTRONICS PARTS of brass and beryllium-copper made by new etching process. Long piece at left was formed after being etched out.

Parts can be produced by the new method having a maximum dimension of 27 x 30 in. By close nesting of each part on a sheet of this size, almost any number of parts can be made in a relatively short time. It is estimated that about 90 per cent of the sheet stock can be used effectively by this method as compared to 75 per cent for mechanical stamping methods.

Two specially compounded acid resists are used to coat metals to be etched. With suitable etchants, about 0.001 in. per min can be cut, and by increasing the base etching temperature 20 F the etching time can be cut in half.

Aluminum, copper, bronze, brass, steel, beryllium, titanium, and chrome-plated sheet stock are some of the materials that can be etched. Physical properties of the material will not be effected.

Parts up to 0.006 inches thick can be produced with a vertical edge. Parts thicker will have a minute shoulder with a radius roughly equal to the depth of the etch. At the present time the process is being limited to a maximum etching thickness of 0.040 in. Texas Nameplate Co., 3010 Main St., Dallas, Texas.

For more information—
Circle 3, inside back cover

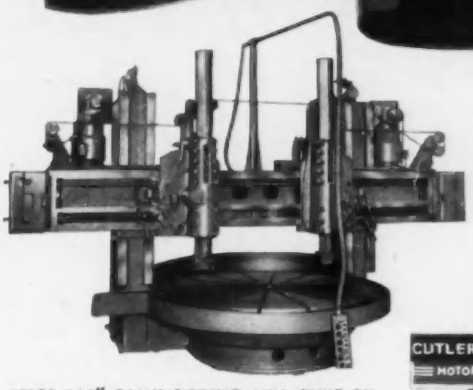
Torque Converter Coupling For Combustion Engines

These single-stage couplings provide a hydraulic power transmission unit for engines developing 180 to 225 ft-lb of torque governed at 2000-2200 rpm or higher.

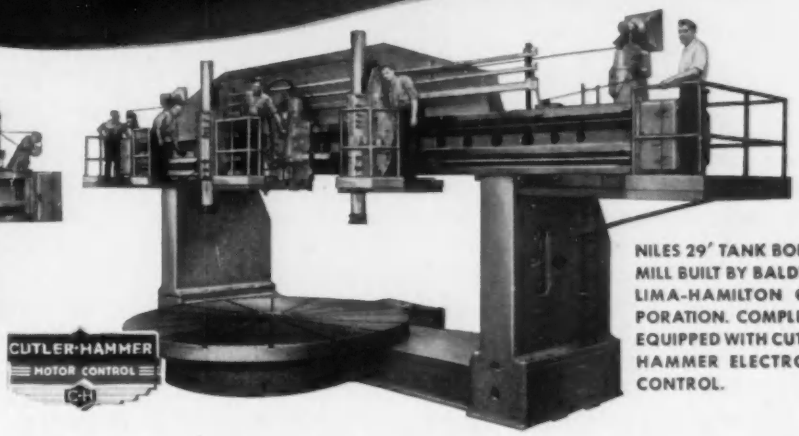
The design of these converter couplings is asserted to offer equipment manufacturers a readily adaptable unit where there is a need for the advan-

CONTINUED ON PAGE 222

CUTLER-HAMMER
MOTOR CONTROL
C-H
CHOICE OF THE LEADERS
THE MARK OF BETTER MACHINES



NILES 120" TANK BORING MILL BUILT BY BALDWIN-LIMA-HAMILTON CORPORATION. COMPLETELY EQUIPPED WITH CUTLER-HAMMER ELECTRONIC CONTROL.



NILES 29' TANK BORING MILL BUILT BY BALDWIN-LIMA-HAMILTON CORPORATION. COMPLETELY EQUIPPED WITH CUTLER-HAMMER ELECTRONIC CONTROL.

INGERSOLL CUTTER GRINDER BUILT BY THE INGERSOLL MILLING MACHINE CO. COMPLETELY EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL INCLUDING CUTLER-HAMMER FRACTIONAL HORSEPOWER ELECTRONIC UNIT.

GRAY 6" PLANER TYPE HORIZONTAL BORING, MILLING & DRILLING MACHINE BUILT BY G. A. GRAY CO. COMPLETELY EQUIPPED WITH CUTLER-HAMMER ELECTRONIC CONTROL.

Better all the way

In every field of manufacture there are a few companies consistently able to better fit their products to the needs of the user. These companies just as consistently win and hold preferred position in their markets. But *better* product means better all the way through, better in the part the company *builds*, better in the components the company *buys* to complete its product. And leading machinery manufacturers that build spectacular new but dependable machines capitalizing on advances in electronic control engineering refuse to compromise. They turn to electronic control by Cutler-Hammer, leader in motor control design for more than half a century, and now leader *as expected* in pioneering and developing electronic control. Cutler-Hammer is your safe choice for proved dependable and efficient electronic control. CUTLER-HAMMER, Inc., 1332 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

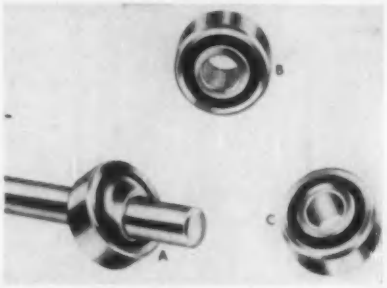
tages of automatic torque multiplication. The Model 12-T coupling is equipped with SAE No. 3 housing at the output end for the application of automotive clutch and mechanical transmission. Model 12-U is equipped with a 1¾-in., 10-spline shaft for straight line drives with universal joint. The Model 12-H is available with a flanged output shaft for the attachment of industrial-type couplings.

Installation of the torque converter couplings is recommended by the manufacturer where intermittent heavy loads and starts-and-stops threaten to overwork engines, transmissions, axles, brakes, tires and operators. The fluid cushion provided by the coupling absorbs and eliminates shock loads and dampens out torsional vibrations.

Torque demand is matched to the load through 2.1:1 torque multiplication of the converter. As the load levels off, the converter automatically adjusts to smooth, economical fluid coupling operation. Operators can crowd the load at all times, without engine lugging or stalling. The engine is always operating in the high, efficient range, no matter what the load or speed of the vehicle. Fuller Mfg. Co., Kalamazoo, Mich.

For more information—
Circle 4, inside back cover

MECHANICAL COMPONENTS



Self-Aligning Bearings and Bushings

"Ball-action", self-aligning bearing or bushing with the inner and outer parts separated by a molded natural rubber, Buna S, Buna N, Neoprene or silicone cushion, was designed to solve a specific problem in ordnance vehicles. Thousands are in successful use for intermittent reciprocal motion of a shaft (A). For rotary motion, needle bearings (B) or a bronze bushing insert (C) can be supplied. It is now being made available for civilian and other governmental use.

The molded rubber or neoprene forms a cushion between the two metal parts of the bearing. This cushion combined with the ball-action self-aligning feature reduces and absorbs vibration, shock and sound. These bearings and bushings are made specially, ordinarily, but a few sizes are stocked. A. J. Berna Co., 20160 Sherwood, Detroit 34, Mich.

For more information—
Circle 5, inside back cover

Torque Limiting Overload Protection Devices

This line of machinery drive overload protection devices has high-friction, wearproof friction disks and a new adjusting nut locking arrangement. They act as automatic shear pin mechanisms and avoid the time and labor required to insert new shear pins.

The drive component is mounted on a powdered metal bushing in the torque limiting unit and clamped between two friction disks by the action of an adjustable Bellville spring. When an overload is imposed on a machinery drive, the sprocket or related drive component breaks away from the clutch disks and slips at from one half to one third the torque setting until the motor is shut off and the overload condition is corrected. No resetting is needed to make the device operative after the overload is removed.

The new friction disks, which are not bonded to the clutch plates, are an asbestos, phenolic resin and brass chip mixture molded under high pressure. This produces a lining having stable friction qualities under a wide range of temperatures and pressures and which does not absorb oil or moisture. The new disks have a friction coefficient of 0.35. They replace former asbestos and rubber-phenolic composition disks having a 0.25 friction co-efficient.

A setscrew and a brass plug locking assembly has been added to the cast iron adjusting nut to avoid adjusting problems in drives where vibration is present.

These new torque limiting units are available in eleven standard models having maximum torque capacities from 20 to 620 ft-lb. Outside diameters are from 2 to 3⅞ in. They can be mounted on shafts from ½ to 2½-in. dia. Morse Chain Co., 7601 Central Ave., Detroit 10, Mich.

For more information—
Circle 6, inside back cover

Stainless Steel Coupling

These couplings are designed for medium speed operation and permit a slight angularity and misalignment of two shafts. The unit has a high torque shaft-to-shaft coupling with zero backlash.

All parts are stainless steel, passivated to military standards. There are three basic shaft sizes, ⅛, 5/16 and ¼-in. dia. Set screws are provided for holding and sub-drill holes for fixed pinning. As many as six different shaft-to-shaft combinations are available. Pic Design Corporation, 160 Avenue, Lynbrook, New York.

For more information—
Circle 7, inside back cover

Automatic Over-Running Clutches

The over-running mechanism in these clutches is combined with a floating shaft which will compensate for both parallel and angular alignment errors without imposing excessive load on the bearings in the clutch.

CONTINUED ON PAGE 224

if
you
need
to

stop electricity

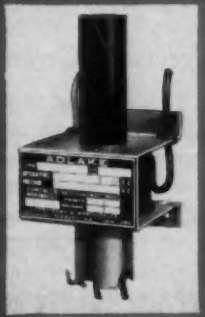
for
a
precise
interval

it'll pay you to look into

Adlake

mercury relays

Adlake relays require no maintenance whatever... are quiet and chatterless... free from explosion hazard... dust, dirt, moisture and temperature changes can't affect their operation. Mercury-to-mercury contact gives ideal snap action, with no burning, pitting or sticking. Time delay characteristics are fixed and non-adjustable.



Adlake 98th year

The Adams & Westlake Company
Established 1857
ELKHART, INDIANA • New York • Chicago

the *original* and largest manufacturers of mercury plunger-type relays

Both type couplings will also accommodate an end float, but Type 96 is constructed with special clearance to permit an unusual amount of axial expansion.

The coupling is designed particularly for boiler fan drives, where the heat of the hot gases handled may cause expansion and misalignment. They are also suggested for installations where the supporting members may be subject to deflection which would affect the shaft alignment.

By removing a few screws and bolts, the floating shaft assembly can be lifted out of the drive. This provides plenty of room for inspection, maintenance and repair without disturbing the mounting of the nuts. Hilliard Corp., 100 W. 4 St., Elmira, N. Y.

For more information—
Circle 8, inside back cover

Automatic "Spider" Clutch For Gasoline Engines

The only moving parts in this clutch are the four friction segments riding on a rubber spider, held in positon by a garter spring. One half of the pulley is part of the stamped steel housing. The "spider" clutch is adaptable to V-belt, sprocket or direct coupling drive.

Operating through centrifugal force controlled by the engine throttle, the clutch works equally well in either direction. It is claimed that the clutch will eliminate the necessity of a belt tightener, hinged engine or supplementary controls and that it gives load-free starting and idling.

This new clutch is designed particularly for use in gasoline powered units up to 3½ hp, where price is an important factor. Automatic Steel Products, Inc., 1201 Camden Ave., S. W., Canton 6, Ohio.

For more information—
Circle 9, inside back cover

Telescoping Steel Slides

Heavy-duty telescoping steel slides, fabricated of sheet metal, have been developed to facilitate movement of fixed objects or materials from in-use to storage positions within aircraft compartments. The slides, available as counterpart pairs, are presently manufactured in two sizes: a 24-in. long model with an 18-in. telescoping travel supports a 150 to 250 lb load when extended. The smaller pair operating from a spring-action trigger, carries a 75 to 150 lb weight load when extended. Universal Metal Products, Inc., Alhambra, Calif.

For more information—
Circle 10, inside back cover

Variable Speed Transmission

This transmission is especially designed for applications in the ¼ to 1 hp range which require a speed range of 3 to 1 or less. The unit consists of double variable pulleys on a ball-bearing equipped countershaft, which can be pivoted laterally between the drive and driven pulleys. This change in center distances adjusts the variable pulleys to new running diameters, and speeds selected are maintained by a handle and locking knob.

The pulleys are made of machined cast iron, and operate on precision ball bearings for efficient operation. Pulleys are smooth-sided rather than inter-locking, and both pulleys are on the same side of the mounting frame for more compact installation.

The transmission has 5-in. pulleys, gives a speed range of 3 to 1 with "B" section belts. Overall dimensions are 8 x 8 x 10 in. with a weight of 15 lb. Standard Transmission Equipment Company, 70 West Union Street, Pasadena 1, California.

For more information—
Circle 11, inside back cover

Precision Ground Shafting

This shafting is designed to fit certain ball bearings of ABEC-7 quality. Immediately available from stock in three basic shaft sizes, ⅛, ⅜ and ½-in. dia, and in lengths up to 16 in. long in ⅛ in. steps. Shafting is centerless ground to a tolerance of ±0.0001 in. Ball bearings of the make and type used with this shafting is available in "Barden" plain and flanged styles, made of stainless steel. Pic Design Corporation, 160 Atlantic Avenue, Lynbrook, New York.

For more information—
Circle 12, inside back cover

One Seal Combines O-Ring And Back-Up Functions

A seal for hydraulic and pneumatic applications fits into a standard groove having the recommended width to accommodate an O-ring and two back-up rings. Sealing is effected by interference at low pressures. At high pressures a lip type of seal develops as a result of pressure distortion of the seal.

The new seal is said to eliminate spiral failures and to minimize seal wear and extrusion. It is recommended primarily for difficult high pressure applications. Sili-Craft Rubber Corporation, 1700 West 135 Street, Gardena, California.

For more information—
Circle 13, inside back cover

Small Socket Screws Now Standard

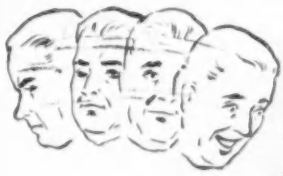
A complete line of socket head cap and set screws in sizes from No. 4 (0.112 in.) down to No. 0 (0.060 in.) are now being offered as standard items for the first time, according to the manufacturer. Both 18-8 stainless steel and heat treated alloy steel, in a variety of lengths and threads, are available. The socket screws are available in either the "hex" socket or the multiple spline socket. Many sizes are stocked for immediate delivery. Bristol Co., Waterbury 20, Conn.

For more information—
Circle 14, inside back cover

Double Setscrews

A setscrew with a pivot shaft point, for use as a locking or adjusting screw in double screw installations, has just

CONTINUED ON PAGE 226



YES SIR! 16% PRODUCTION INCREASE

at

Progress Manufacturing Company

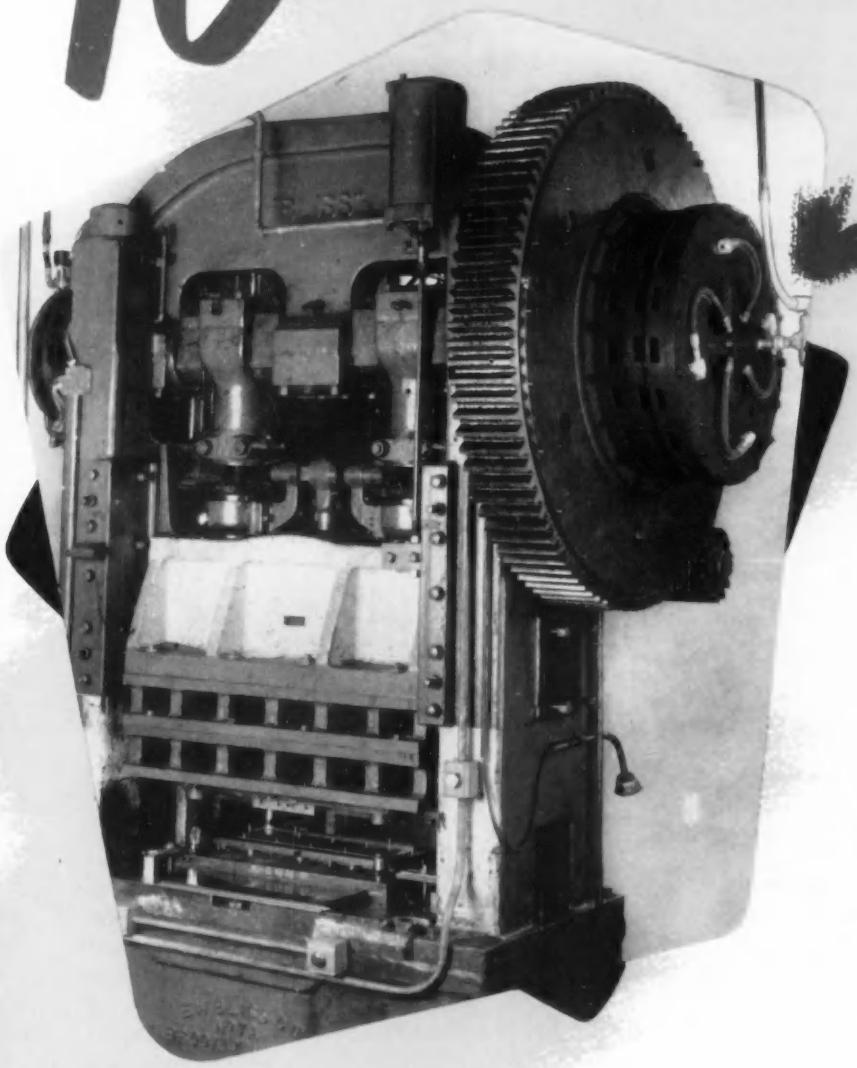
of Philadelphia, Pa.

with **WICHITA**

LOW INERTIA

Air-Tube

CLUTCHES & BRAKES



What a difference! Now, that Progress Manufacturing Company, a leading manufacturer of outdoor lanterns and lighting fixtures, has converted this Bliss 7A Press to a Wichita Clutch and Brake operation.

Ultimate outcome — increased profit for the company, higher rate of pay for employees — and the conversion of a LIABILITY to an ASSET without a major investment . . . plus a safer operating press, more easily controlled, and one which turns out better parts.

Further Proof that PROGRESS is PROGRESSIVE

Modernize by converting your presses and other equipment to Wichita Clutches and Brakes!

Manufactured by

WICHITA *Clutch*

COMPANY, INC.

WICHITA FALLS, TEXAS, U.S.A.

For Complete Information

CONSULT YOUR NEAREST WICHITA ENGINEER

WICHITA DISTRIBUTORS

Brehm-Lahner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
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Smith-Keser & Co., (Main Office) West Hartford, Conn.
Smith-Keser & Co., Philadelphia 44, Pa.
Smith-Keser & Co., New York, N. Y.
Frank W. Yarline Co., Chicago, Ill.
Power Rig & Equipment Co., Inc., Long Beach, Calif.
Robert R. King Co., Cleveland, Ohio
John C. Burge, Oklahoma City, Oklahoma
Dominion Power Press & Equipment Ltd., Toronto, Canada

been announced. Elimination of damage to the second screw, and prevention of loosening due to the turning of the ganged screws as one, are among the advantages claimed.

The pivot screw has a shaft protruding from the end. This shaft is pointed and fits into the socket of the screw ahead of it, which is to be locked or held in adjustment. Thus, the point on which the top screw turns provides the only contact between the two screws. In spite of the positive holding action, both screws can be easily removed when desired. Set Screw & Mfg. Co., 153 Main St., Bartlett, Ill.

For more information—
Circle 15, inside back cover

Heat and Corrosion Resistant O-Rings and Gaskets

Resistance to chemical attack, high temperatures, an extremely low coefficient of friction and elimination of contamination of taste, odor or coloring of foods, drugs or high purity chemicals is said to be achieved with a line of O-rings. Made of Teflon, these seals introduce in plastics the principle of the line contact compression seal. That is, when under compression, the total load is distributed over a very small area, resulting in extremely high psi values. When properly engineered into the equipment, the new O-ring can seal effectively in both static and dynamic applications.

These new components are available in two standard series, equivalent to "AN" O-Ring sizes and tolerances. More than 140 sizes are available from $\frac{1}{8}$ to 11 in. OD. Chicago Gasket Co., 1271 W. North Ave., Chicago 22, Ill.

For more information—
Circle 16, inside back cover

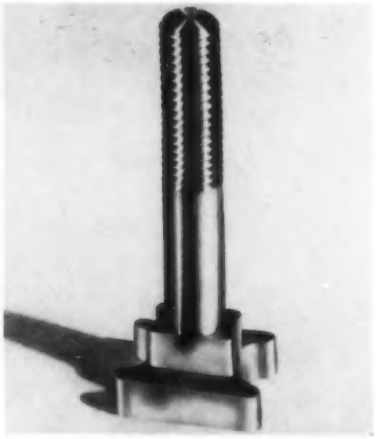
T-Slot Bolts Have Concave Heads

The concave head automatically cleans out the slot as the bolt travels on the work table. Dirt and chips are pushed to the center of the slot instead of to the sides. This avoids the jamming or binding of square or angled head bolts, especially when they are worn or fit loosely.

This construction is said to add more than 50 percent to the bearing surface. This increased under-slot traveling surface assures greater rigidity, with less chance of job slippage or breaking out of slots.

The new T-slot bolts are heat treated to give three to four times greater strength and coined after forging to assure precision surfaces. They are given a special "blue-black" rust-proof coating. SAE 4140 steel is used.

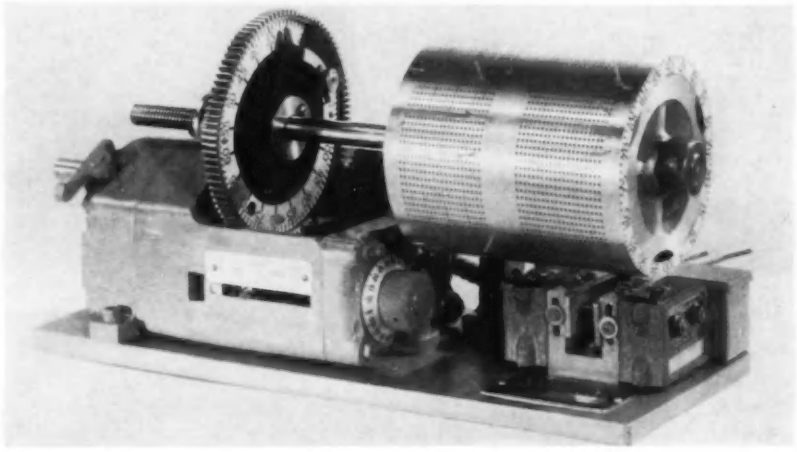
These bolts are available in: $\frac{1}{2}$ in. dia, from 2 to 18 in. long under the head; $\frac{5}{8}$ in. dia, from $2\frac{1}{2}$ to 18 in. long under the head; $\frac{3}{4}$ in. dia, from $2\frac{1}{2}$ to 24 in. long under the head. Also available in $\frac{7}{8}$, 1, $1\frac{1}{8}$ and $1\frac{1}{4}$ in. dia.



Standard Parts Co., 1000 Broadway, Bedford, Ohio.

For more information—
Circle 17, inside back cover

POWER AND CONTROL



Counter-Controller Operates At Up to 4000 Rpm

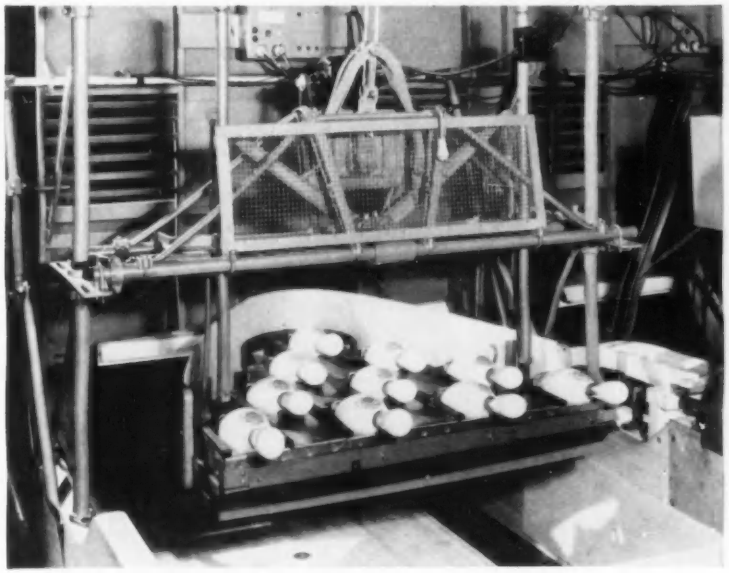
Operating entirely on electro-mechanical principles, this switching device is said to provide a virtually unlimited choice of switching points in a count-cycle which this switching is said to provide. Predetermination of count-cycle settings over a broad range of numbers is possible and, in addition, the selection of any number of intermediate switching points within the chosen count-cycle.

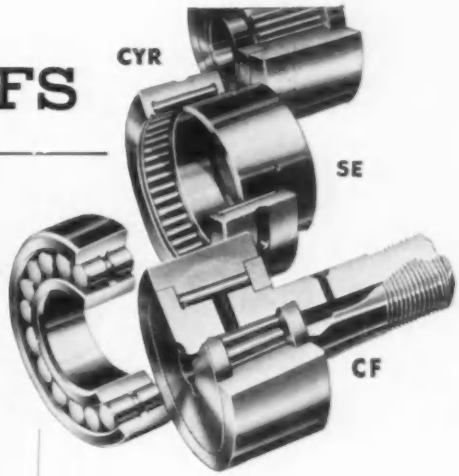
Reset for recycling is instantaneous and automatic. Even at speeds as high as 4000 rpm, the switching pattern produced by the integral control circuit may be repeated without slowdowns or stops between cycles, if necessary. Models are available for counting shaft revolutions, lever strokes and electric impulses.

Intermediate switching points are determined by the response of sensing switch actuators to a pattern on a *program cylinder*, which alternately

CONTINUED ON PAGE 228

McGILL BEARING BRIEFS





CAMROL CF bearings ADD TO SAFETY of 22,000 Brunswick-Balke-Collender semi-automatic pinsetters now in use

When the pinboys "set 'em up in the other alley" a McGill CAMROL Cam Follower helps them do the job without danger to themselves or damage to the pin-setting machine.

Known as the B-10 Semi-Automatic Pinsetter, this machine is a product of The Brunswick-Balke-Collender Company and is in use on 22,000 individual bowling lanes throughout the world.

In these machines the CAMROL CF bearing is used in the safety latch mechanism to lock the cam action and prevent the machine from recycling during pin setting. Used by the company for 4 years, the CAMROL bearing has given no trouble despite the literally millions of cycles these 22,000 machines have been operated.

CAMROL Cam Follower bearings utilize a full complement of small diameter followers with outer race and integral stud and flange custom heat treated for the ultimate in radial and shock load capacity.

Precision tolerances on all grinding surfaces with simplified lubrication minimizes internal wear and increases bearing life. Both starting and running friction are reduced to a minimum.

McGill designed and built the first Cam Follower and used 20 years of experience with thousands of applications to perfect the right Cam Follower for any cam action application.

BEARING SELECTION GUIDE

A revised 140 page Bearing Selection Guide, complete with 30 pages of vital engineering data, has been released by the McGill Manufacturing Co. Ask for Catalog No. 52.

CAMROL CF BEARING USED from BEGINNING of PRODUCTION by SCHIELD-BANTAM COMPANY

More than 5,500 cranes and excavators built by Schield Bantam since 1945 use CAMROL CF Bearings in SHIFTING COLLAR vertical swing shafts and drum clutch applications. With maintenance negligible and performance excellent the manufacturer asserts, "Using CAMROL CF Bearings offers an overall price advantage and insures maximum product quality."

PINES PRESSURE DIE HOLDER PUTS up to 18,000 POUND LOAD on CAMROL CYR BEARING

Pines Engineering Co., Inc., has used the CAMROL CYR Bearing for 6 years in tube bending machines and has never had a failure. The bearing takes the full bending moment in Pines pressure die holders that bend extra heavy pipe in sizes ranging from ¾" to 4" without scratching the tubing.

50th McGILL Anniversary

McGILL design leadership has given you these important developments

★ First full type roller bearing ★ First guided full-type roller bearing ★ First Cam Follower roller bearing ★ First sealed roller bearing

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

traverses two switches. Reversal of cylinder movement is accomplished by a patented clutching action.

Program cylinders are furnished in two forms. For momentary switching, the cylinder can be arranged for any switching patterns desired by locating small, self-locking pins in holes in the cylinder. It is possible to operate the control circuit at any or all numbers, as they occur, in the count-cycle. For dwell switching, the program cylinders are cut to special order and changes in the switching pattern are effected by the quick and easy interchange of cylinders on the main chassis.

Basically, the unit is a single circuit controller. However, by working through a stepping relay, it may be utilized for multi-circuit requirements. The new controller-counter is expected to find application in the automatic control of machinery, processes, displays and experiments where switch functions must occur at numerous irregular intervals in a count-cycle which must be repeated. Both the count-cycle and intermediate switching points can be varied. Counter & Control Corp., 5213 W. Electric Ave., Milwaukee 14, Wis.

For more information—
Circle 18, inside back cover

Miniature Drive Motor Weighs 5½ Oz

Designed as a drive motor for switches, cams, servos and similar equipment, this miniature motor has a motor diameter of 1⅛ in. 2 ⅞ in. in length, and the gear case is 1½ in. dia. Mounting flange has a 2½ in. dia.

The new drive is for any input of 6 to 30 v, dc, and for any output speed from 4 to 10 rpm. Maximum torque load at 4 rpm is 50 in.-oz, with a lower rating for higher speeds. It can be supplied with either leads or feed-through solder connections to meet customer requirements; and may also be supplied with governor control.

The new motor has an aluminum alloy case with molded plastic brush housing. Ball bearings are sealed and greased for the life of the unit. El Ray Motor Co., N. Hollywood, Calif.

For more information—
Circle 19, inside back cover

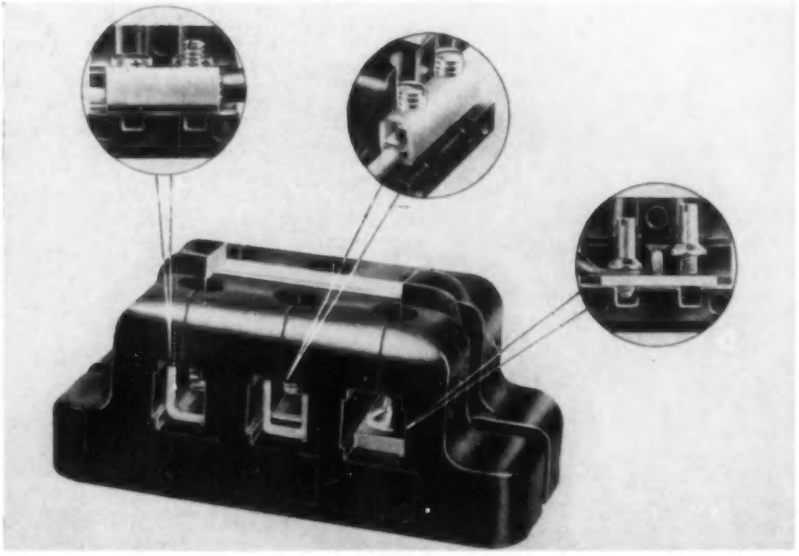
Miniature Permanent Magnet Motor

When equipped with a new type of gear train that reduces as high as 1600 to 1, this motor is said to be capable of replacing motors several times its size. Available in six different models, with or without gear reduction units, the motor operates with a smaller air

Sectional Terminal Block

This block's design allows any number of circuit sections to be securely assembled into a compact 70 amp, 750 v sectional terminal block. One-piece ruggedness of assembled circuit sections is achieved through three integrally molded serrated pins which locate and secure each circuit section by mating with corresponding holes in the adjoining circuit section. This also permits limitless circuit sections to be assembled without the inherent disadvantages of conventional sectional blocks having accessory fastening hardware or loose-fitting sections. These interlocking surfaces are said to have also solved the flashover and leakage problem common to many types of conventional terminal blocks.

Each circuit section is fully covered and is complete with a factory-installed contact. Three contact types are available for stripped or terminal-ended wire, with a range of No. 18 through No. 4 wires. All contacts are plated electrolytic copper with positive wire stops. With maximum wire sizes installed in all contact types, contact screws never project above the block.



Sections are available either factory-assembled or in sections for user's assembly with pneumatically or manually operated assembly fixture. Slip-fit sections are available for user's hand assembly and disassembly.

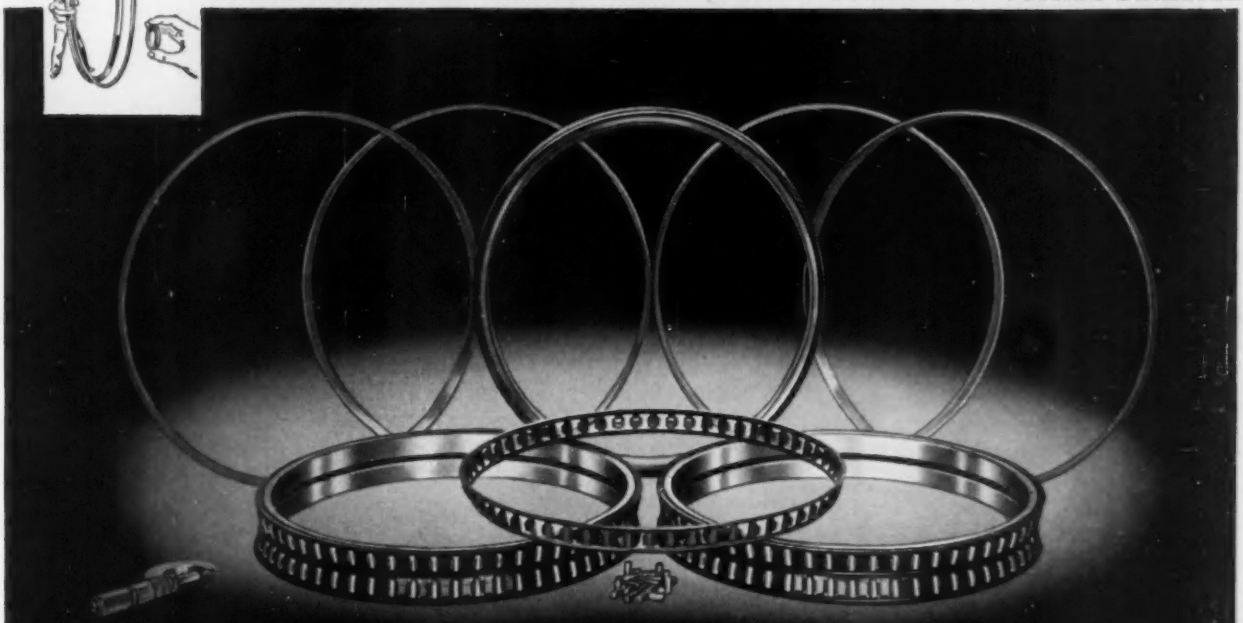
User's assembly inventory has been simplified by use of only three basic parts for complete block. Snap-in marking strips do not require fastening hardware. These blocks are interchangeable with conventional blocks of similar ratings and are supplied in various MIL-P-14 molding materials. Buchanan Electrical Product Corp., 225 Route 22, Hillside, N. J.

For more information—
Circle 20, inside back cover

CONTINUED ON PAGE 230

Contact KAYDON Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER



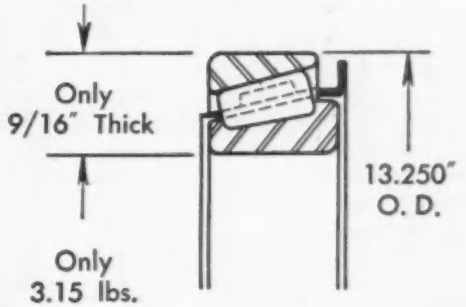
KAYDON single row, tapered roller bearings 12.125" x 13.250" x .718"
Total bearing weight: 3.15 lbs.

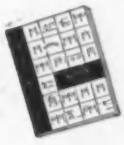
KAYDON creates world's THINNEST tapered roller bearings—REALI-SLIM as a wedding ring

Here's another first by **KAYDON** of Muskegon. We now offer the *thinnest* single row, tapered roller bearings ever made. Even a bride's modern wedding ring, made to proportionate size, would not be as thin or light in weight as one of these *Reali-Slim* bearings.

If you're faced with bearing problems, which involve conserving space and weight, consult **KAYDON** while your product design still is on the drawing board. Remember — for standard bearings or bearings of unusual design you can depend on **KAYDON** for the engineering skill and manufacturing facilities to do your job. It pays to contact **KAYDON** first!

Details of thin section, lightweight bearing shown above





Write for engineering catalog!

For complete data on capacity, seals, separators, standard and *Reali-Slim* "wedding ring" bearings, ask for catalog No. 54.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

KAYDON types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

K-551

PRECISION BALL AND ROLLER BEARINGS

gap than is customary, without any deterioration of commutation and without increasing the loss in field shoes. This is due to a special shape and laminated construction. Mica insulation is employed in the commutator. The motors were designed to use extra-large brushes to guarantee longer life, better commutation, lower rf noise and greater output from a given package. Armature laminations have seven slots and are skewed full slot to assist commutation and to minimize changes in magnetic reluctance.

The combination of specially shaped field shoes, skewed laminations and optimum brush size enables this motor to operate with no 'latching effect'. This is said to permit use in servo applications.

The motor, weighing only 3¾ oz and 2 in. in over-all length, is so designed that modifications of speed, torque and other performance characteristics can be made to make the motor available at moderate cost. Airquipment Co., Inc., 2248 E. 37 St., Los Angeles, Calif.

For more information—
Circle 21, inside back cover

Skeleton and Clutch-Gear Fhp Motors

According to the manufacturer, these motors have high starting torque, a simplified means of mounting and low cost. The skeleton type motors are two-pole, shaded pole, available from 1/500 to 1/25 hp with operating speeds of 2100 to 3500 rpm. Voltage range is 6 v, ac, to 220 v, ac, 50 or 60 cycle. Maximum torque is 14 in-oz running, and 10 in-oz starting, clockwise or counter-clockwise rotation. Shaft sizes up to ⅛ in. dia are available and stock sizes of ⅛ to 2 in. Mounting centers are 2⅜ in. Bearings are self-aligning, with oil reservoir. Thrust bearings are available and the motor operates in any position.

The clutch-gear type motors are two-pole, shaded pole, featuring compact size and a fast disengagement time of approximately 25 milliseconds. Available in all speeds from 4 to 328 rpm. Voltage range is 6 v, ac, to 220 v, ac, 50 or 60 cycle. An example of maximum torque: at 25 rpm, torque is 100 in-oz on continuous duty; on intermittent duty, range is increased. Rotation may be either clockwise or counter-clockwise. Shafts permit single or double output, and sizes of ⅛ to ⅜ in. dia are available. Either nylon or metal gears are supplied.

No lubrication is required and the

Quick-Response D-c Motors

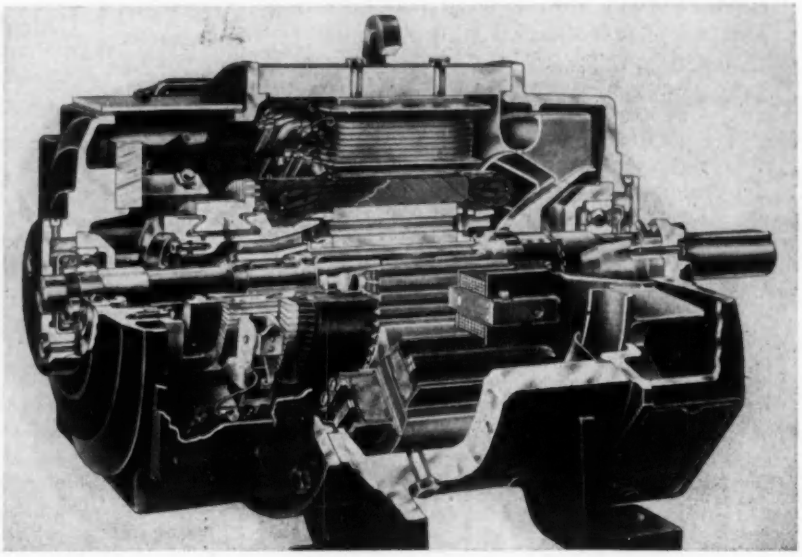
These d-c motors are said to start, reach speed and stop with a rapidity and accuracy normally achieved only with specially designed drives. Made in a range of sizes from 20 to 250 hp (to be extended soon both upward and downward), it is possible to accelerate the 100 hp model to 1200 rpm in 0.5 sec. Speed regulation has been held within 0.1 percent.

Speed range by field control was planned for 6:1, but ranges up to 50:1 and even higher are obtainable through the addition of regulatory equipment. Horsepower output of the protected adjustable-speed motor increases to about a third above normal when this new motor reaches three times base speed. Low speeds for jogging and creeping, and reversal with controlled acceleration, are normal functions of this drive.

The quick-response characteristics of this new motor are obtained with five basic armature diameters, each with the lowest possible inertia and the largest possible commutators. Class B insulation materials are used in both the armatures and field coils, permitting use of these motors where service temperature rises as much as 60 C. Electrical time constants (electrical inertia) of the armature have been lowered by employing fewer turns of wire. These developments have also made possible smaller over-all motor diameters.

Air for cooling is conducted not only over the surfaces of the armature and coil area but also through the commutator by a series of ducts under the winding. All of the new line of d-c drives are totally protected. Enclosure types include those for forced ventilation, forced ventilation with filters, pipe ventilated, totally enclosed (fancooled), totally enclosed (dual cooled). Besides the standard foot mounting, motors with flange and face fixtures are available. Reliance Electric and Engineering Co., 1076 Ivanhoe Road, Cleveland 10, Ohio.

For more information—
Circle 22, inside back cover



CONTINUED ON PAGE 232

DON'T LET THE BIG ONES SCARE YOU!

➡ **1¼" and 1½" diameters**
Standard and from stock
in all listed lengths!
Individually packaged

➡ **Up to 3" in diameter in any length you want. Blanks for these big babies *Right in Stock!***

* (or the small ones either!)

HOLO-KROME
Completely Cold Forged
SOCKET SCREWS

Always quickly available
through HOLO-KROME
Authorized Industrial Distributors

THE HOLO-KROME SCREW CORP. • HARTFORD 10, CONN., U. S. A.

unit is totally enclosed. Over-all size is 3⅜ x 2¾ x 2 7/16 in. Versatile multi-stud mounting is adaptable to a wide range of mounting positions. Comar Electric Co., 3349 Addison St., Chicago 18, Ill.

For more information—
Circle 23, inside back cover

Unidirectional Small Motors

Combining high starting torque with exceptional power output, these motors are available in three stack thicknesses and nine power ratings from 1/200 to 1/40 hp. Oil-impregnated porous bronze bearings, a selection of mounting arrangements and stainless steel hardened and ground shafts are provided. Typical power applications include industrial instruments, fans, small pumps, animated displays, toys and other devices and appliances. Barber-Colman Co., 1200 Rock St., Rockford, Ill.

For more information—
Circle 24, inside back cover

Miniature A-c Motors 1-1/16 In. Dia.

These motors are for applications where size and weight are the governing factors. Protection in accordance with military environmental specifications has been considered in the design. They can be wound for single-phase, two-phase or three-phase, either 60 or 400 cycle. The new a-c motor can be furnished as an induction or hysteresis type. It can also be furnished with a concentric spur gear reducer. Globe Industries, Inc., 1784 Stanley Ave., Dayton, Ohio.

For more information—
Circle 25, inside back cover

Miniature Drive Motor Weighs 5½ Oz

This permanent magnet d-c motor was designed as a drive motor for switches, cams, servos and similar applications. Diameter is 1⅛ in., and length is 2-7/16 in. Gear case diameter is 1½ in., and the mounting flange has a 2½ in. dia.

This gear timing motor may be designed for any input voltage of 6 to 30 v, dc; and for any output speed from 4 to 10 rpm. Maximum torque load at 4 rpm is 50 in-oz, with a lower rating for higher speeds. It can be supplied with either leads or feed-through solder connections, and is available with governor control, if desired.

The new motor has an aluminum alloy case with plastic molded brush housing. Ball bearings are sealed and greased for the life of the motor. The armature assembly has been built to rigid engineering and manufacturing specifications to insure long life and trouble-free operation. El Ray Motor Co., N. Hollywood, Calif.

For more information—
Circle 26, inside back cover

Two-Phase, 30-Cycle Motor-Alternator

This unit has a two-phase, 30-cycle output at 18.5 v. The rotor shaft, extended at both ends of the motor-alternator, permits the unit to perform several functions simultaneously. Power output is equivalent to 2.7 w from the shaft and 1.37 w of electrical power. Input is 115 v, single phase, 60 cycles at 26 to 30 w.

Model HA-2 weighs 6 lb. It is about 7 in. long and 3½ in. dia. Electric Motors and Specialties, Inc., Garrett, Ind.

For more information—
Circle 27, inside back cover

Alternator Electrical Systems

A line of 6, and 12-v alternator electrical systems has been announced that is competitively priced with a standard d-c system. Models include a light-duty unit and a heavy-duty unit, both with capacities of 12-v, 50 amp; also available are a light-duty model and a heavy-duty model with capacities of 6 v, 60 amp.

These devices are expressly designed for fleets of small trucks used for delivery purposes by dairies, bakeries, laundries, dry cleaners, and other such firms. Leece-Neville Co., 5109 Hamilton Ave., Cleveland 14, Ohio.

For more information—
Circle 28, inside back cover

Servo-Gear Motor 1-1/8 In. Dia.

Weighing 4½ oz, various rpm and torque combinations are transmitted through this miniature motor's precision-cut gears mounted in ball bearings. Modifications include hysteresis-synchronous and capacitor induction motors at various voltages and frequencies.

The new motor operates from an input voltage of 115 v, two-phase, frequency 400 cycles. No-load speed is 180 rpm, full load, 135 rpm. Gear reduction is 28.4. Eastern Air Devices, Inc., 381 Central Ave., Dover, N. H.

For more information—
Circle 29, inside back cover

Rotary Heater Switches

A series of rotary heater switches for both two and three-wire systems have spade terminals and a spindle which may be extended through the back of the base to provide unitized control of other components. Designed principally for electric ranges, the extensible spindle may be used to control gears, dampers, other switches or accessories with one dial. Bases are designed to permit use of two, four or six dummy spade terminals to eliminate need for separate blocks. Auxiliary live terminals may also be added.

Single or double pole arrangements are available, with from two to ten positions (off-on, three to nine heats). Series 910 switches may also be had with special circuit variations and motor rated circuits. Standard ratings include 15 amp, 120-240 v; 20 amp, 1 hp, 120 v, 2 hp, 240 v; ½, ¾, 1 hp, 120 v; 1, 1½ and 2 hp, 240 v, ac only. Small dc and special ratings are also available.

Bases of the new switches measure

CONTINUED ON PAGE 234

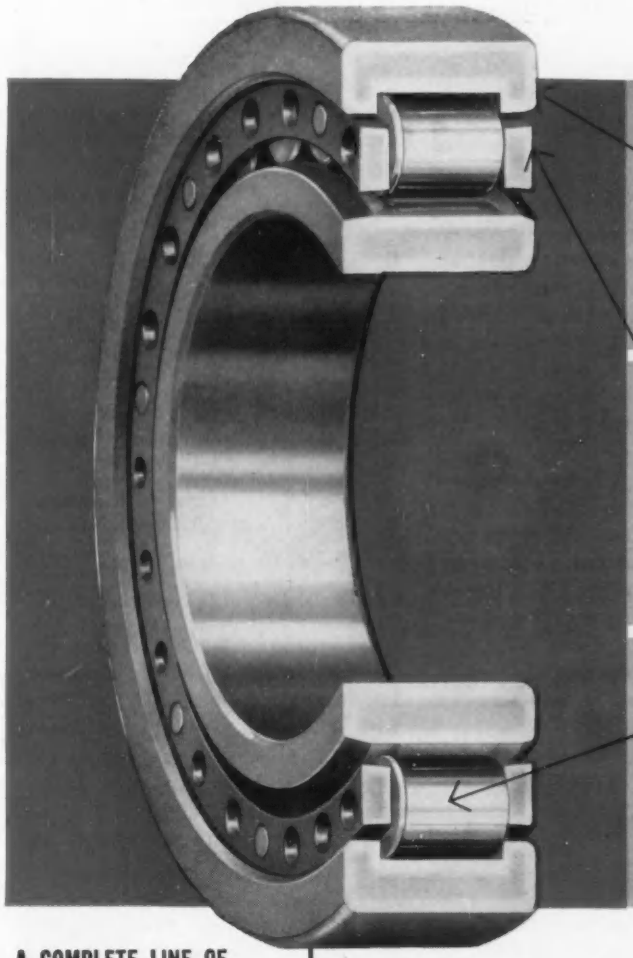
Here's why BOWER straight roller bearings can carry maximum loads—with less maintenance!

The important design features of Bower straight roller bearings shown on this page are just a few of the reasons why these bearings will operate efficiently and economically in your product. Consider these facts, too. Bower straight roller bearings incorporate highest quality materials and workmanship. They have proved themselves capable of standing up day in and day out under maximum loads—with little or no maintenance.

In fact, this is the reason why Bower straight roller bearings are used extensively by leading manufacturers in such fields as automotive, earthmoving, farm equipment and machine tool.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the blueprint stage.

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN



● ***TWO-LIP RACE INCREASES RIGIDITY.*** These two shoulders, made parallel, are integral with the outer race. This provides a more rigid, durable construction. Rollers are kept in proper alignment at all times.

● ***COMPOSITE STEEL CAGE DOES NOT CONTACT ROLLERS DURING NORMAL OPERATION,*** thereby allowing free movement of the rollers between the races. Projections on the inner faces of the rings engage indentations on the roller ends preventing the rollers from dropping out of position when the separable race is removed.

● ***PRECISION-BUILT ROLLERS AND RACES ARE MADE TO SUPPORT MAXIMUM RADIAL LOADS.*** Only the highest grade steel-alloy is used, and rollers and races are precision ground to give quieter, smoother operation. Running clearance is built in at the time of manufacture.

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS FOR EVERY FIELD OF TRANSPORTATION AND INDUSTRY

BOWER

ROLLER BEARINGS

SPHERO HONED

$1\frac{37}{64}$ x $1\frac{31}{32}$ x $\frac{7}{8}$ in. Spindle lengths, including spindle extensions, may be varied as needed. Single or two-hole mounting arrangements are standard but special mounting arrangements may also be had on special order. Space terminals and contact fingers are one-piece, heavy, specially tempered phosphor bronze, with line posts of copper. Operation is on the slow-break principle. Hart Mfg. Co., 110 Bartholomew Ave., Hartford 1, Conn.

For more information—
Circle 30, inside back cover

Rotary Actuator of 0.7 Hp Rating

This actuator is a 0.7 hp unit, 200 v, 400 cycle, three-phase. Locked rotor torque is 12 lb with 11,200 rpm input and 38 rpm output, 7 amp, continuous duty. It can be rotated 330 deg, ±2 deg in either direction. Western Gear Works, P. O. Box 182, Lynwood, Calif.

For more information—
Circle 31, inside back cover

High Temperature Rectifiers

Cell sizes have been increased to 5 ×6 in. on rectifiers which operate without derating at 125 C. These units have until now been almost prohibitive even for military uses, because of high price and size limitations.

The new series of selenium rectifiers can also be hermetically sealed without derating. At 125 C they have a minimum guaranteed life span of 500 hr without derating. At normal temperature they will last almost indefinitely. They can also be supplied in cartridge type if desired. Radio Receptor Co., 251 W. 19 St., New York 11, N. Y.

For more information—
Circle 32, inside back cover

Double-Purpose Generator

A two-phase indicating sine-wave, and two 10-deg pips 180 deg apart, coordinated to one of the phases, are produced by this new generator. Delivering a 13-v, 20-cycles per sec output at 1200 rpm, the standard generator has a normal voltage tolerance in production of ± 0.15 v, while over a load range of more than 4 to 1, output voltage is held to ± 0.5 v. Harmonic content, nominal at 3 percent, averages approximately 0.8 percent. Current rating of the generator is 0.015 amp per phase, with a substantial overload factor—particularly under favorable environmental conditions. Weighing 19 oz, the Type GPM-3 generator has a $3\frac{1}{4}$-in. dia at the mounting flange and a 4-in. overall length. Dalmotor Co., 1362 Clay St., Santa Clara, Calif.

For more information—
Circle 33, inside back cover

Hermetically Sealed Selenium Rectifiers

These high-voltage selenium rectifiers were designed for use in airborne equipment, where adverse atmospheric conditions, severe vibration and rigid electrical specifications must be met. Model U100HM takes a maximum a-c input of 3300 v, rms. Output rating is 1420 v, dc, and 1.5 ma, d-c current at 35 C ambient temperature into a resistive load. At 71 C temperature (typical airborne ambient) this unit delivers 1.2 ma d-c current at 1360 v, dc, from 2130 v, rms a-c input. Of tin-plated brass, this selenium rectifier measures $5\frac{1}{8}$ in. overall length, with a $\frac{5}{8}$ in. OD. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

For more information—
Circle 34, inside back cover

Weigh 4 Oz, Handle 5 to 12,000 Psi

Miniature, pressure actuated switches are now being made that are adaptable to any mounting or envelope requirement. Calibration is unaffected and field adjustment is not necessary. Housings are of cast aluminum.

Service temperature range is from −65 F to 275 F. Sensitivity throughout this temperature range is $3\frac{1}{2}$ per cent at 3000 psi, 5 per cent at 500 psi, 10 per cent at 100 psi. Electrical rating is 17 amp inductive at 24 v, dc, 15 amp inductive at 115 v, ac, 7.5 amp at 230 v. ac. Leach Relay Co., 5915 Avalon Blvd., Los Angeles 3, Calif.

For more information—
Circle 35, inside back cover

Self-Cooled Servo Weighs 3.188 lb.

The motor alone pulls as much as 1/15 hp at 6000 rpm and has 22 in-oz of stall torque. Overheating of the servo motor is prevented by a blower which functions independently yet is an integral part of the servo. The device was originally designed to drive an antenna on airborne military radar, and is expected to prove applicable to other applications requiring absolute dependability with compactness and powerful response.

The servo is a two-phase, 115-v, 400-cycle motor with a no-load speed of 10,000 rpm and a full-load speed of 6000 rpm. Stalled power input is 150 v per phase. Acceleration is 31,000 radians per second squared, min. Rotor inertia is 50 g-cm², max. The blower is a single-phase, 115-v, 400-cycle motor. Power input total is 35 w. John Oster Mfg. Co., Racine, Wis.

For more information—
Circle 36, inside back cover

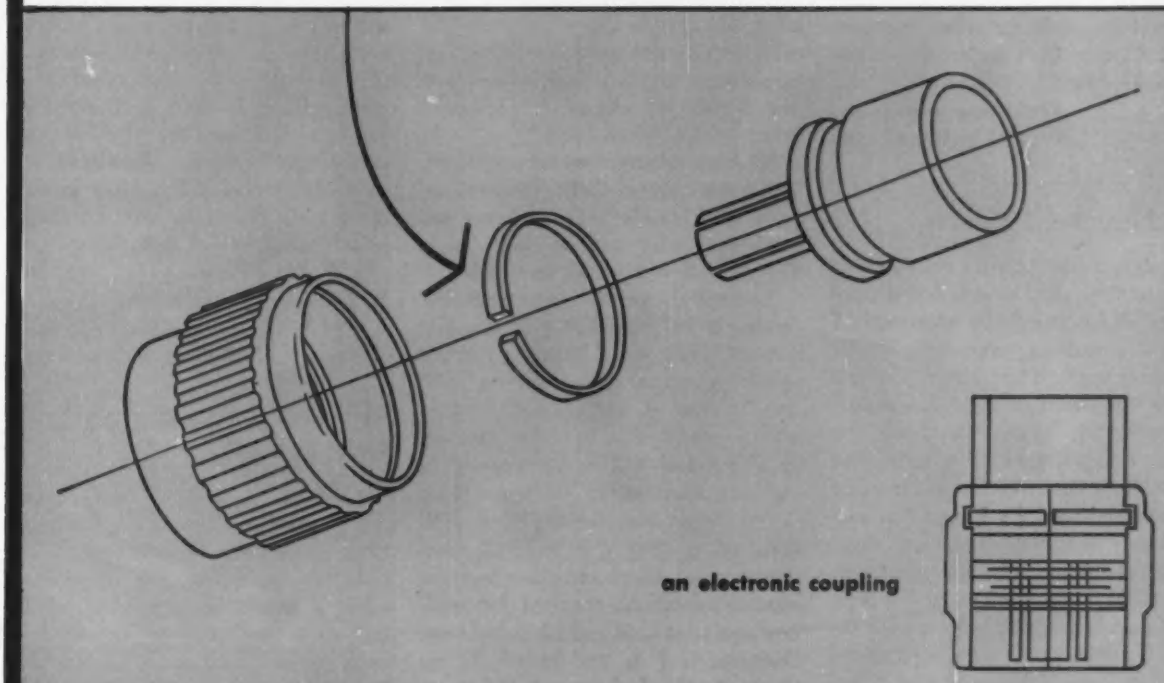
Heavy-Duty Stepping Switch

Designed for operation extending beyond 100-million steps, (impulse or self-drive) this switch, when fitted with up to five double-ended wipers, has a speed of 68 steps per second. When fitted with up to eight double-ended or ten single-ended wipers, the speed of stepping is 60 steps per second average.

Armature stroke is set by a simple adjustment of the knife-edge suspension, in full view of the front. The interrupter springset is adjusted by setting the camber of the base plate by means of two securing screws. Bank contacts, wipers, collector rings and brushes are made of nickel-silver for

CONTINUED ON PAGE 236

REDESIGN TO SAVE TIME AND MATERIAL



an electronic coupling

Examine the designs of *all* of your products and machines. No doubt you can use retaining rings on axles and in housings—*not only to save assembly time, but to save weight, parts and space.*

Many manufacturers have not only increased their profits but have also improved their products by using these high-grade rings, fabricated in various metals. Their uses are varied—ranging from heavy-duty engines and drill presses to toys, gadgets and small parts of articles made of metal, wood or plaster.

Don't pass up opportunities to increase your profits; let our engineers consult with you.

THE NATIONAL LOCK WASHER CO.

NEWARK 5, NEW JERSEY — MILWAUKEE 2, WISCONSIN

maximum wear resistance. The mechanism is designed for use with standard 25-contact banks, and by the simple expedient of fitting a new wiper-brush assembly, it can be used to replace existing mechanisms. The standard range of coils covers 22, 40, 50 and 60 v, d-c operation. Coils can be specially made for other voltages. Imtra Corp., 58 Charles St., Cambridge 41, Mass.

For more information—
Circle 37, inside back cover

Machine Tool Switch

Designed especially for the machine tool industry, this switch has a snap action. It has repeatedly withstood 25 million actuations, according to the manufacturer. The silver contact points are reversible and the terminal compartment is separate from the switch compartment. The roller and pin in the standard actuator are made of hardened steel for longer life, and the heavy cast aluminum case is gasketed for oil and moisture resistance.

Model L-100S provides 70 deg overtravel and is available with a wide variety of actuators. It may be mounted at either side or from the top. Electrical rating is 25 amp, 125 v, ac-dc. Acro Mfg. Co., Columbus 16, Ohio.

For more information—
Circle 38, inside back cover

Current and Voltage-Sensing Relays

These thermal-type relays are hermetically sealed and their operating points are adjustable by means of a screw outside the sealed space. Applications include overload protection, over-and under-voltage alarm or cut-off, voltage regulation, and battery charge control.

The contact circuits in these relays operate when current or voltage reaching their heaters exceeds the operating point for which the relay is set. They release their contacts when the current or voltage drops below this value. This operating point is adjustable for each relay, either at the factory or by the user, over a 2:1 range. Nine different internal structures are available with time constants ranging from 1 sec to 2½ min, so that a relay may be chosen which will be affected by overcurrent or over-voltage at the same rate as the protected equipment. The action of the thermal relay then parallels that of the protected equipment, operating quickly on a heavy overload or other greatly abnormal condition, but tolerating a slight deviation from normal current or voltage for a longer time.

All types of structure are contained in the same size of shell. All are made both in a plug-in form for seven-pin miniature tube sockets and in a flanged style with solder terminals.

The relays operate interchangeably on d-c or on a-c current of any frequency. Differential between contact operating and release currents or voltages is about 1 per cent. Operating setting can be made to ±4 per cent or closer and will not change with ambient temperature by more than ±5 per cent over the range of −70 C to 100 C. The relays will withstand the vibration, shock and other environmental conditions required for military equipment. Weight is 1 to 1½ oz. Diameter is ¾ in. and length 2⅜ in. Contact rating is 3 amp at 115 v, ac, non-inductive load or at 28 v, dc, non-inductive. Contacts are single-pole, single-throw and may be ordered either to close or to open on current or voltage rise. Relays are available for operating currents from 0.015 to 5 amp and for voltages from 1 to 230 v. G-V Controls Inc., 28 Hollywood Plaza, East Orange, N. J.

For more information—
Circle 39, inside back cover

Sensitive Relay That Requires 25 Milliwatts Per Contact

Relays combining high sensitivity with thorough wiping action on each contact are available hermetically sealed or with dust cover. Bounce and chatter are said to be eliminated by the built-in wiping action in the contact movement.

Designed for d-c applications, drop-out of the unit can be adjusted to about 65 percent of the pick-up. Capacity is up to 1 amp inductive and 3 amp resistive load with coil resistance to a maximum of 30,000 ohm. Available in single-pole, single-throw up to double-pole, double-throw contacts.

The effect of residual magnetism and iron aging are eliminated by nonferrous metals and hydrogen annealing of the magnetic components. Hermetic sealing is done exclusively by welding. Dust-covered type has accessible spring-screw adjustment for changing the contact pressure as well as the pick-up and drop-out characteristics. Hedin Tele Technical Corp., 640 W. Mt. Pleasant Ave., Livingston, N. J.

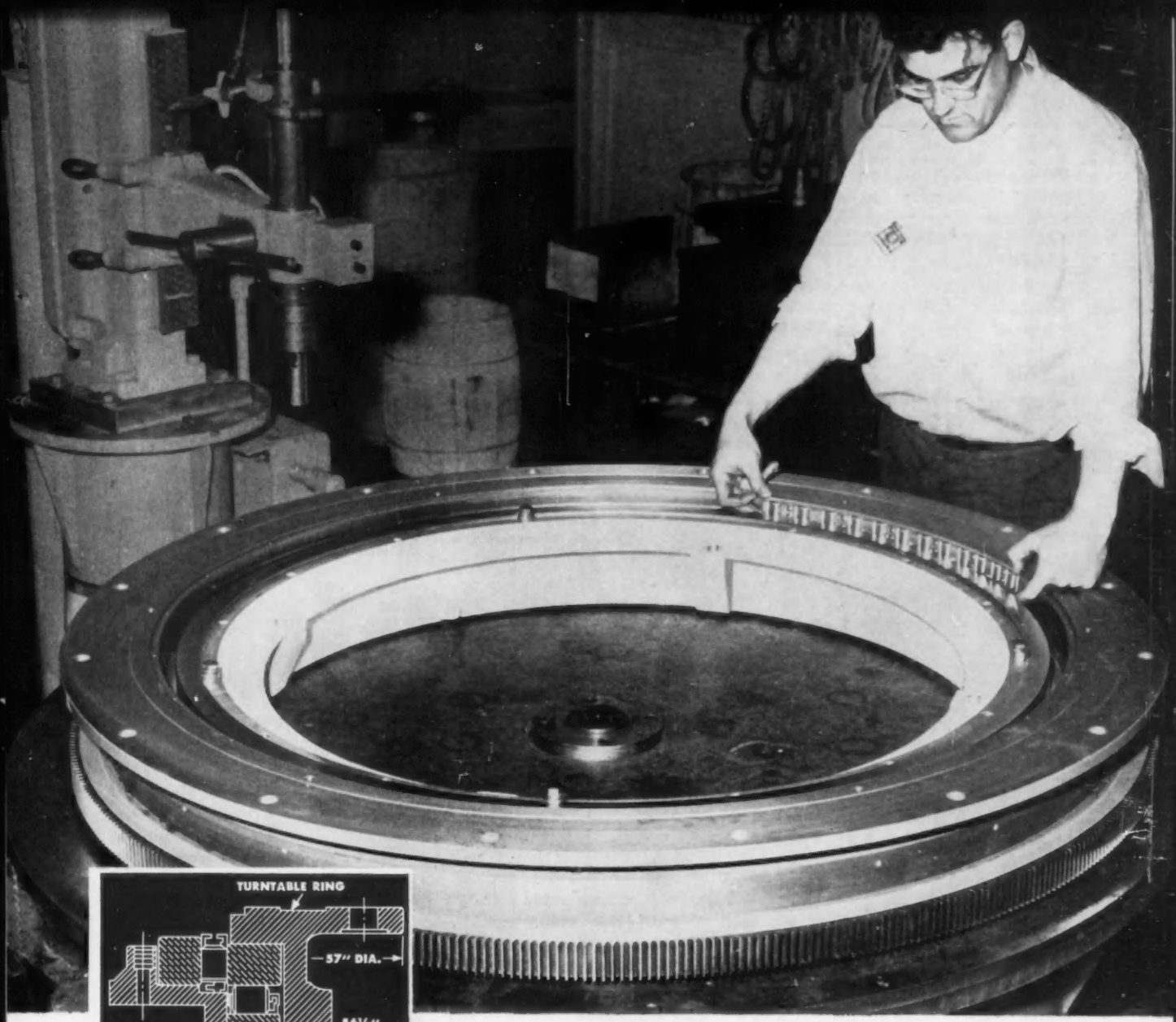
For more information—
Circle 40, inside back cover

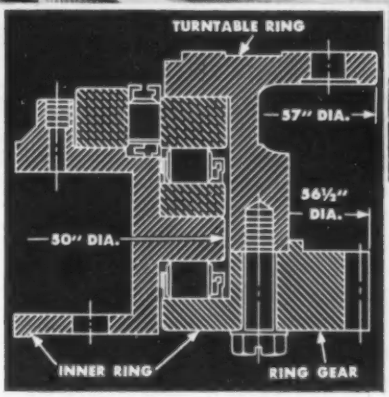
Miniature, Single Coil Relays

Available in 1 to 5 amp contact ratings, and in contact combinations from single-pole, single-throw to six-pole, double-throw, the new relay offers a maximum sensitivity of 15 milliwatts per pole in the double-pole, double-throw combination. This is an optimum combination, withstanding 10 g vibration from 10 to 500 cycles. When power is increased to 40 milliwatts per pole, vibration resistance rises to 30 g. Sensitivity and vibration resistance decrease as additional contact combinations are added with the same amount of power.

According to the manufacturer, several new design features contribute to the extremely high efficiency of the SQ series. Friction-creating hinge pins are eliminated, and the use of a beryllium copper armature retaining spring insures positive contact between armature and pivot point at all times. Cross-bar palladium-type contacts are always properly aligned. A long nylon bobbin, rigidly fastened to the frame and core assembly by means of a snap-ring, permits the selection of many types of wire insulation, and allows, in addition, the winding of any type of coil including multiple and matched windings. No

CONTINUED ON PAGE 238





Switch to SSW forged rings in bearing assembly adds to "ultra-accuracy" of naval gun director

Three forged rings which are the major parts of this bearing assembly for a naval gun director contribute to required "ultra-accuracy." By switching to Standard Steel forgings in two of these rings General Electric Company, Pittsfield, Mass., gets *all* these benefits.

1. The 57-in. O.D. turntable forged ring (formerly a casting), improves uniformity and stability of the metal, its machinability, and reduces required machining.
2. Proper heat treatment and precision machining give extreme smooth rotation on the roller bearings and accurate positioning without backlash.
3. Production has been simplified and speeded up and fabrication costs reduced.
4. The stationary 50-in. O.D. inner ring eliminated a weldment consisting of five rings cut from steel plate.
5. These rings cost less than cast rings in the quantities needed.

You, like General Electric, will benefit by using Standard Steel Works forgings. It'll be to your advantage to check how profitably SSW forged rings can replace weldments and castings. Why not write today for more information? Please address Dept. 8735, Standard Steel Works Division, Baldwin-Lima-Hamilton Corp., Burnham, Pennsylvania.

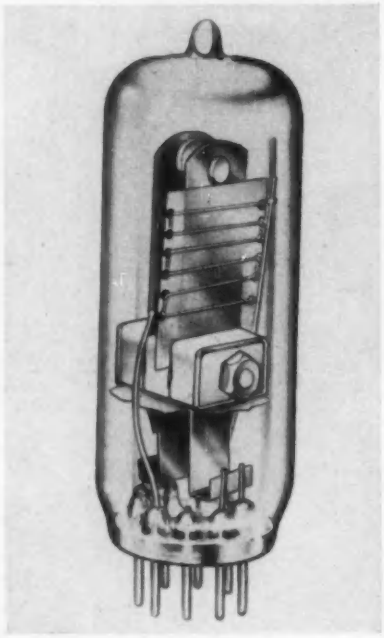
Standard Steel Works Division
Burnham (Mifflin County), Pa.

BALDWIN-LIMA-HAMILTON
General Offices: Philadelphia 42, Pa. • Offices in Principal Cities

organic insulation is used in this high-temperature relay—the unit is insulated with silicone glass, Kel-F or Teflon tubing. Movable blades are actuated by ceramic bumpers, with nylon or linen-base bakelite optional.

Dimensions of the open-type relay are 1 × ¾ × 1$\frac{5}{16}$ in. Advance Electric & Relay Co., 2435 N. Naomi St., Burbank, Calif.

For more information—
Circle 41, inside back cover



Hermetically Sealed Differential Relays

These differential relays may be used for automatic overload, over-voltage, under-voltage or under-current protection. They reset automatically when the abnormal condition is removed. Since the actuating element is a heater, the relay may be designed for time constants varying from approximately 3 to 30 sec. It will not respond to transients of shorter duration. Available in single-pole, single-throw, normally open or normally closed. Completely isolated contacts makes many circuit variations possible. The relays can be designed for currents from 10 to 1000 ma, voltages from 1 to 100 v. Higher currents can be handled by an external contactor. Approximately 1 w is required for the heater. However, the relay will withstand 100 per cent overload indefinitely.

The new relay is available in either the standard octal base or nine-pin miniature. They are pre-set at the factory. Standard tolerance of voltage or current for opening and closing is ±10 per cent. Closer tolerances are available on special order. Being hermetically sealed, they are said not to be affected by changes in temperature, pressure, or humidity. Amperite Co., 561 Broadway, New York 12, N. Y.

For more information—
Circle 42, inside back cover

Pneumatic-Actuating Capacitive Level Control

Capacitive level sensing with electronic controls terminating in air-pressure variations suitable for operating a pneumatic-diaphragm control valve are combined in a new level control. Applicable to most non-adhesive chemicals, milk, oils, refrigerants such as ammonia and the Freons, and all condensed gases over a temperature range from 425 F to 500 F, the control derives a sensing signal from an inert capacitive-type probe which is assertedly capable of being operated in applications ranging from high vacuum to pressures as great as 100,000 psi. The probe is connected by coaxial cable to the electronic circuitry, which can be located as far as 1000 ft from the sensing point.

Responding to a rising or falling level around the probe, the electronic unit actuates an air-pilot valve which modulates a 15-psi air supply over a range from 3 to 15 psi. This pneumatic signal can be used directly to actuate small control valves or, where greater volumes of air are necessary, can be fed into auxiliary control equipment. Units can be supplied for operation arranged so that the main valve either opens or closes with increased pressure.

Housed in a cast-aluminum box, 6½ x 11½ x 4 in., the control unit includes a meter for observation of the output of the electronic control unit and an air-pressure indicating instrument for observation of valve operation. Panel-front controls located under screw-on dust-protective caps provide for coarse level adjustment, fine level adjustment, and differential in range of control (proportional-band adjustment). The complete instrument packed for shipment weighs 18 lb. Thermo Instruments Co., 1310 County Road, Belmont, Calif.

For more information—
Circle 43, inside back cover

Hermetically Sealed Miniature Relays

These units are ¾ × $\frac{15}{16}$ × 1⅜ in. and weigh 1 oz. They are available in both single-pole, double-throw and double-pole, double-throw models. Contact ratings are up to 5 amp resistive at 28 v, dc, 115 v, ac, or 3 amp inductive. Temperature range is 55 to 125 F. Operational life is in excess of 1 million cycles under 1 amp resistive load. Pacific Relays, Inc., 6819 Melrose Ave., Los Angeles 38, Calif.

For more information—
Circle 44, inside back cover

Hermetically Sealed Contact Relays

These relays are said to differ from conventional ones in that they operate on a principle that lends itself to sealed contact construction and makes possible fast response, high operating speeds, high sensitivity and low capacitance along with low contact resistance. Made by enclosing two magnetic cylinders in a sealed envelope and causing the magnetic cylinders to contact each other by bringing a magnetic field into close proximity, closing a pre-set gap between the cylinders, these relays are characterized by compact construction and a large variety of operational characteristics.

These new relays have their magnetic contacting elements sealed in a glass envelope and are actuated by an electromagnetic coil mounted about the element assembly. Noble

—CONTINUED ON PAGE 240

for

Exacting

CYLINDER CONTROL

¼" UNITITE JR. VALVES

Hanna ¼" Valves control air, oil or water pressures up to 500 p.s.i. The control lever requires only 80° movement for reversal. Hanna ¼" Valves are 4-way but can be made 3-way, by plugging one port. Three models — column, standard and manifold mount—are available. Ideal for tubing and light piping.

ELECTRIC VALVES

The Hanna 4-way Solenoid Valve is small, compact, with low current consumption. It is adaptable to straight line piping—capacity is equal to rated pipe size. Of balanced spool type, it has a built-in solenoid pilot valve. Piping may be from bottom, sides or a combination. Available in ⅜", ½", ¾" and 1" pipe sizes.

Hanna® valves

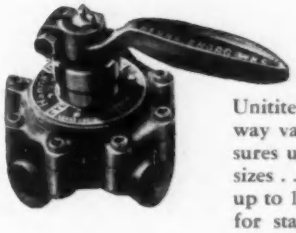
CHOOSE FROM a broad selection of Hanna Valves to meet your requirements for exacting Air and Hydraulic control. Illustrated are but a few of the complete line of hand, foot, electric and pilot operated valves for directional and speed control. They all carry the Hanna nameplate—an assurance of extraordinary care in design and manufacture—which means years of maintenance-free operation. Your Hanna sales representative offers specialized experience in selecting valve combinations and developing control circuits.

SEND FOR BULLETIN

Write today for the new illustrated Hanna Valve Bulletin No. 257.

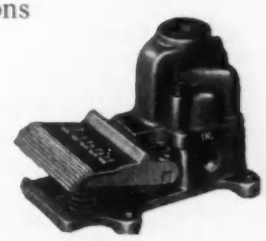
SPEED CONTROL VALVES

Hanna Flo-Set Valves have micrometer graduations to assure exacting speed control. Available in ¼", ⅜", ½" and ¾" sizes, they are suitable for air, oil or water control, with maximum pressure to 250 p.s.i. They may be mounted in any position.



UNITITE VALVES

Unitite Valves are suitable as either 3-way or 4-way valves, operating at air, oil or water pressures up to 250 p.s.i. for the ⅜", ½", and ¾" sizes . . . up to 150 p.s.i. for the 1" size . . . and up to 100 p.s.i. for the 1¼" size. Three styles—for standard mounting, column mounting or manifold mounting—are available.



FOOT OPERATED VALVES

Available in ⅜", ½", ¾" and 1" pipe sizes, Hanna Foot Valves are ideal for applications where it is desirable to have the operator's hands free for handling material. Single-pedal and double-pedal models, for pressures up to 250 p.s.i., are available for use with double-acting air and hydraulic cylinders.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1763 Elston Avenue, Chicago 22, Illinois

metal contacting surfaces are welded onto the elements for low contact resistance and high resistance to corrosion; the sealed case can be filled with atmosphere at pressure or with any number of inert or reducing gases, depending on the application; coils can be supplied for constant current or constant voltage applications, and coil specifications can be varied to meet requirements of sensitivity and operating speed.

Because of their long life (1 billion cycles), and high switching rates (up to 60 cycles per sec), these relays can be used in high speed switching applications (average actuating speeds are 1.0 to 2.0 milliseconds). Single and multiple element units (up to 109 contacts) are available, and simultaneous contact closure on multiple element units is within 1 millisecond. Other models having permanent magnets for actuation or biasing, and models having two coils for differential or pulse operation, are available on special order. G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.

For more information—
Circle 45, inside back cover

Controller Has On-Off Or Throttling Action

An indicating controller in the low price range is reported to provide sharp on-off or narrow band proportional control of such variables as temperature, pressure, liquid level and humidity.

When equipped for on-off action, the new controller "snaps" the control valve from fully opened to fully closed when the measurement crosses the control point, handling any process with large capacity-demand ratio and negligible lag.

For a process requiring throttling action, the Model 41A is equipped with a proportional unit adjustable from 0.25 up to 25 per cent of scale. The unit, a simplified blast feedback proportioning mechanism, relies on air jet rather than bellows-actuated "follow-up" action.

"Left-to-right" indicating scale with white-on-black numerals and graduations has been lengthened to 5 in., improving readability and accuracy. Internal components, many of them standard parts of the older model of this same control, have been rearranged to simplify routine instrument maintenance. Case is 11 x 9 x 4¾ in. Foxboro Co., Foxboro, Mass.

For more information—
Circle 46, inside back cover

Cartridge Thermostat Will Take Mechanical Clamping

It is reported that this metal thermostat will withstand mechanical clamping of its cartridge without effecting the set calibration. There is complete lack of reliance on the expansion of the outer shell for make and break of contacts, so slight pressure on the outer shell will have no effect. Operating ranges of 0 to 600 F are available. The unit is rated at 1200 w, 115-230 v, ac, non-inductive load.

A completely sealed assembly is used to prevent contamination of parts. Lead wire is protected from strain. Calibration is unaffected by vibration. There is an easily accessible, self-locking adjustment screw. Model FM-132 is available with normally open or normally closed contacts, as required. Outer shell can be of brass, stainless steel or special alloy to meet individual requirements. George Ulanet Co., 418 Market St., Newark 5, N. J.

For more information—
Circle 47, inside back cover

Fail-Safe Combination Fan-Limit Control

Designed for gas, coal or oil-fired systems, this control's limit switch is factory set and is of the single-pole, single-throw type. The unit's limit lever system checks every fan cycle. Both the fan switch and the limit switch (tested at 1800 v) have fixed differentials and are actuated by a single thermal element. This can be furnished in various lengths and responds instantly to temperature changes. A single stainless steel diaphragm actuates both fan and limit. Dust-tight switches are fully enclosed and summer settings are provided for continuous fan operation. The fan cut-out temperature is adjustable and easily set by a finger-tip adjustment. Continuous fan operation is obtained by setting of the fan temperature dial. This combination fan-limit control is of the remote bulb type and may be bent to avoid reflecting or radiating surfaces in the furnace. Fail-safe mechanism incorporated in the design eliminates any danger from control failure. The unit can be surface mounted in any position, as off level mounting will not affect calibration. Perfex Corp., 500 W. Oklahoma Ave., Milwaukee 7, Wis.

For more information—
Circle 48, inside back cover

Thermostatic Pilot Controller

This pilot controller, measuring only 3⅛ in. in width, provides accurate temperature control of liquids or air when used in conjunction with valves, dampers and other controls. It is readily employed in control systems of electro-plating tanks, dyeing and bleaching machinery, chemical vats and processes, instantaneous water heaters, sewage disposal systems and other applications in which rapid response and adjustable control characteristics are required, the manufacturer claims.

The sensitive rod-and-tube thermal element of the instrument is immersed directly in the medium being controlled. This controller may be installed in any position, vertically, horizontally or diagonally.

Any change in temperature at the thermal element activates a small pilot valve, which in turn varies the control pressure applied to a motor valve or any other final control device. The operation of the final control device governs the amount of either cooling or heating applied to the medium under control.

The instrument is well suited for use with compressed air, water or any clear, low-viscosity hydraulic medium. It is designed to control temperatures in wide adjustable ranges from 50 to

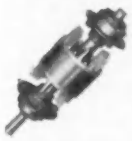
CONTINUED ON PAGE 242

A *Century* MOTOR With

Gas Mask PROTECTION

Underwriters Approved EXPLOSION PROOF MOTORS

Take a look at these *Century* Explosion Proof Motor features:



- Vital motor parts protected—sealed into inner frame.
- Motor can be reversed without changing direction of the fan—fan runs in either direction.
- Uniform ventilation surrounding outside of inner frame.
- Smooth, straight-through ventilating passages.
- Winding electrically insulated 6 different ways.
- Unusually free from vibration.
- Ball bearing housing keeps grease in—dirt out—lubricated for several years' normal service, with grease plugs for additional lubrication, if necessary.
- Easy-to-remove fan guard is held securely in place with two screws.
- Smooth exterior surface is easy to clean.
- Cast iron frame with integrally cast feet resists rust and corrosion—even when mounted in places where processed materials may contact the feet.
- Rugged construction gives generous safety factor for rough handling.

CE-773

Your property and employees are protected, because this Century Explosion Proof motor is totally enclosed—sealed to prevent a motor spark from causing an explosion.

Class I, groups C and D are used in atmospheres containing flammable gases or vapors: Ethyl ether vapors, gasoline, petroleum, napthha, alcohols, acetone, lacquer solvent vapors and natural gas.

Class II, groups E, F and G are used in atmospheres containing combustible dusts: Metal dust, carbon black, coal or coke dust and grain dusts.

Naturally, corrosive or abrasive materials in the air are also sealed out of the vital parts.

For your protection specify Century motors on the equipment you design. Century Engineers are always ready to work with you . . . to assist you in selecting the motor which will enable you to get top performance from your machine. These engineers can give you complete information on Century's wide range of motors—from 1/8 to 400 horsepower.

Century C MOTORS

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri

Offices and Stock Points in Principal Cities

250 F and from 150 to 350 F. Other ranges are also proposed. Accurate, easily read gauges indicate both pilot supply pressure and control pressure.

The "proportional band" or effective control differential of the new control device may be adjusted quickly in the field to any spread between 5 and 25 F with an ordinary screw driver. Using ordinary tools, the pilot valve action may be readily reversed in the field in a matter of 20 to 30 min. This includes time for checking the calibration of the instrument. Robertshaw-Fulton Controls Co., Box 400, Knoxville 1, Tenn.

For more information—
Circle 49, inside back cover

Fuel-Air Ratio Regulator

Proportioning the flow of oil and air to an oil burner is accomplished with this regulator, which is installed in the oil supply line. The unit is of balanced valve design. The ratio between the oil diaphragm and the air diaphragm govern the oil discharge pressure of the device. The unit is said to handle satisfactorily inlet pressures of 45 to 75 psi. Hauck Mfg. Co., 124-136 10 St., Brooklyn 15, N. Y.

For more information—
Circle 50, inside back cover

Maintains Rate of Flow Within 1 Per Cent

These constant flow valves maintain the rate of flow of fuel oil or any other non-abrasive fluid within 1 per cent up to 200, 300, 400, 500, 600 or 700 gph as desired. Each model will maintain flow rates as low as 10 per cent of maximum. The valves will regulate the flow of fluids with viscosities as high as 250 ssu at operating temperature, static pressures as great as 500 psi, and temperatures as high as 250 F, despite fluctuations in upstream or downstream pressure. Flow level is accurately maintained as long as the fluid viscosity and temperatures are constant and the pressure differential across the valve is 40 psi or higher for maximum flow.

Flow level may be set manually at the valve or through any one of four optional remote adjusting systems specifically designed to operate in conjunction with the valve. These four systems, one hydraulic, one pneumatic and two electric, may in turn be operated manually or by a pneumatic or electric signal proportional to temperature, flow of another fluid or a gas, or some other variable. In addition, any one of these adjusting systems may incorporate a feedback potentiometer to develop voltage proportional to flow through valve.

The constant flow valve operates by measuring the pressure drop across an adjustable orifice. This pressure differential is applied across a spring-biased hydraulic cylinder connected to operate a throttling valve upstream from the orifice. If the pressure drop across the orifice does not exactly balance the constant force applied by the spring, the resultant piston action causes the throttling valve to re-adjust differential pressure at the orifice to the desired valve, and, consequently, flow to the preset rate. Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.

For more information—
Circle 51, inside back cover

Can Be Soldered Or Cold-Crimped

Produced in continuous form and supplied on reels, these connectors are automatically attached on an attaching machine made by the manufacturer. This device cold crimps or solders and cuts off in one operation. Electric Terminal Corp., 75 Virginia Ave., Providence 5, R. I.

For more information—
Circle 52, inside back cover

Adjustable Air Regulator

A drift-free source of clean, dry air for instrument service or air-regulated equipment is provided by this regulator, which has a flow capacity of up to 15 cfm, inlet pressure of 150 lb max, and automatic relief if the regulated pressure exceeds the pre-set value. Water separation is accomplished by a large-capacity dripwell and resinous bonded filter element 35 times the area of standard ¼-in. pipe. Entire unit is easily cleaned and dripwell is drained by a simple pushbutton valve.

The regulator is 3⅜ in. dia. by 7⅛ in. high (with adjusting screw fully extended). It may be panel, bracket or line mounted. Valve spring is stainless steel, diaphragm nylon and Buna N; body is cast aluminum chemically treated for corrosion resistance. Unit is furnished with or without pressure gauge. Kendall Controls Corp., 144 Moody St., Waltham, Mass.

For more information—
Circle 53, inside back cover

Photoelectric Control Unit

Designed for applications where the light beam is interrupted 100 per cent, this control requires 20 foot-candles min light, with 0.06 sec, min, phototube dark time and 0.06 sec, min, phototube light time. Plate relay is energized when light beam is interrupted. Relay contacts are rated 5 amp at 115 v, ac.

The splashproof cast aluminum case is 5¼ x 3½ x 3⅛ in. Adjustable mounting bracket facilitates alignment with light source.

Available with suitable light sources for operating distances of 2 to 30 ft. Autotron Co., P. O. Box 722-V, Danville, Ill.

For more information—
Circle 54, inside back cover

A-C Outlet Simplifies Parallel Wiring

Furnished pre-wired with two leads on each contact, these multiple outlets can be installed simply by riveting or eyeletting the outlets onto a panel —matching the black and the white coded leads to those of the adjacent outlets and interwiring rapidly by wire nuts.

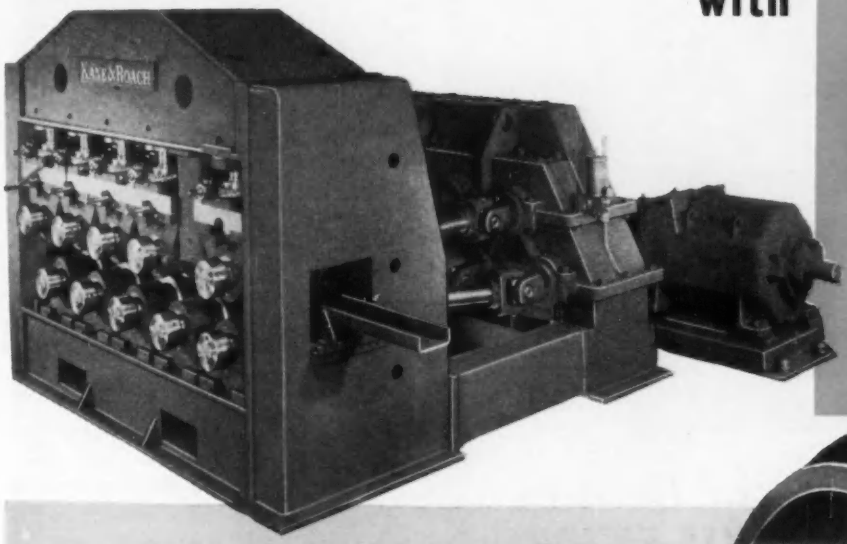
The new outlet mounts with 1⅛ in. mounting hole centers. It requires less than ½ in. wide panel space. Having double leads attached to integral strain relief tabs on each contact, contacts

CONTINUED ON PAGE 244

10-ROLL HORIZONTAL STRAIGHTENER

equips all inboard and outboard roll shafts with

ORANGE "STAGGERED" ROLLER BEARINGS



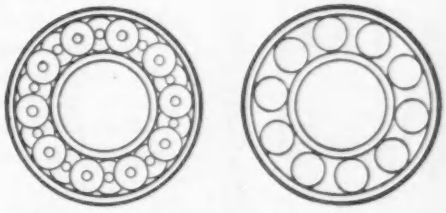
"High radial load capacity—long life—low maintenance cost", reports Kane & Roach, Inc.

The K & R 4AU Horizontal Straightener straightens stainless steel channels, bars, road scraper blades and other heavy sections. Capacity—3″ square stainless steel, 100,000 lb. yield; 5″ x 1″ stainless steel on edge, 100,000 lb. yield. Since 1940, Kane & Roach, Inc., Syracuse, N. Y. has relied upon Orange "Staggered" Roller Bearings to carry the load imposed on the straightener rolls . . . 10 on the inboard and 10 on the outboard roll shafts.

Outstanding for Heavy-Duty Service

Wherever radial loads are extremely heavy and operating conditions are unusually severe, install Orange "Staggered" Roller Bearings. Get extra load capacity, longer bearing life and extra margin of safety for your equipment.

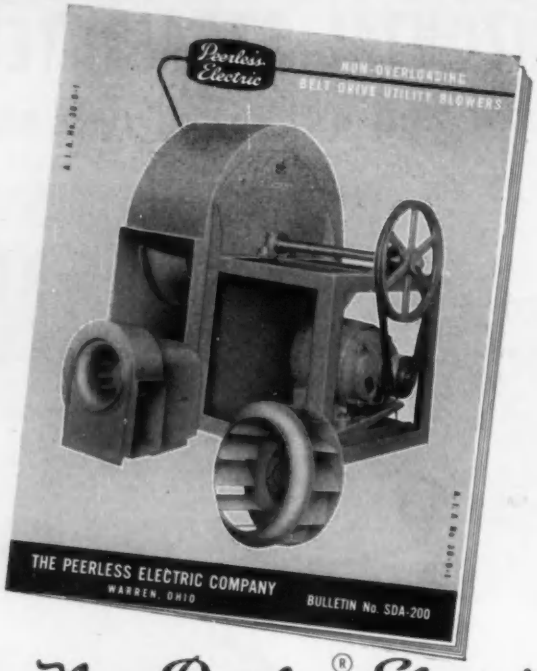
Available in a full range of standard sizes, fully interchangeable with other bearings in complete unit or component parts. Engineering service and stocks in all industrial centers.



End views of a "staggered" roller bearing (left) and a conventional bearing, show how many short rolls, instead of fewer long rolls, distribute the load over a multiplicity of contact points in the loaded zone. This also eliminates skewing tendencies of long rollers—provides closer centers for maximum supporting area—assures smooth, precision running.

Submit your problems to our engineering department. Write for Engineering Data Book.

ORANGE ROLLER BEARING CO., INC., 551 Main Street, Orange, N. J.



The New Peerless® Electric
BACKWARD CURVE BLOWER CATALOG

GUARANTEED RATINGS

A CONCISE GUIDE TO
BETTER BLOWER APPLICATIONS

This fact-packed 36-page catalog tells you everything you need to know about backward curve blowers. It shows the complete range of sizes from 12½" to 36½"; lists all performance ratings for each size at each motor rating; shows all variable speed ranges; gives you finger-tip reference to CFM ratings, outlet velocities, discharges and rotations. All blower performance ratings are guaranteed by Peerless. These facts are your guide to better, more efficient and more economical blower applications. If you require any special design features or engineering aid to develop the proper blower for your equipment, Peerless engineers will work with you to make it possible. Call us today. There's no obligation.

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FAN AND BLOWER DIVISION
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Smoothest Performers
Peerless® Electric
on the Market

and lead connections are completely housed and insulated within the phenolic insulating body, yet the new outlet takes less than 1 in. of space behind the mounting panel. Alden Products Co., 117 N. Main St., Brockton 64, Mass.

For more information—
Circle 55, inside back cover

High Voltage Miniature Connector

The one-piece, molded, mineral-filled melamine insert bodies used in this connector are designed to fit standard AN 20 shells. The plug and receptacle halves can be supplied assembled in any of the 3100 to 3108 solid or split shells required.

Contacts are rated at 5 amp and have solder cups for No. 20 AWG wire. They are gold plated over silver for high conductivity, prevention of corrosion and soldering ease. Contacts are completely protected by telescoping barriers, with additional safety provided by the "make first, break last" center contact if connected to a ground wire.

Weight of the plug insert is 0.4 oz, weight of receptacle insert, 0.3 oz. Voltage breakdown at sea level is 6800 v, dc, at 60,000 ft altitude, 1400 v, dc. Winchester Electronics, Inc., Dept. K, Norwalk, Conn.

For more information—
Circle 56, inside back cover

Metal-Cased Panel Meters

This line of 2½ and 3½ in. meters are anti-magnetic and have front zero adjustments. They are available with either round or square bezels, in a-c and d-c models and null indicators. Phaostron Co., 151 Pasadena Ave., S. Pasadena, Calif.

For more information—
Circle 57, inside back cover

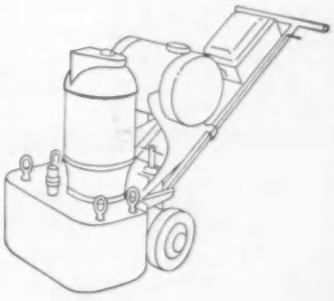
Ceramic-to-Metal Seals Withstand 1400 F and 2000 Psi

These seals are said to be the result of the integration of the metal coating into the ceramic itself. "Wedding" the two materials furnishes a bond for the soldering or brazing of metal parts. A complete line of standard terminals

We gave them a mountain in a molehill

Ever try to remove dried cement with a steel brush? This Peerless Electric motor has a job that's just as tough. It drives a floor grinding machine that polishes stone and cement floors. Our engineers worked with the OEM's engineers to give it more than its rated horsepower, overload capacity, and the ability to overcome tremendous breakdown torque created by grinding wheels flying over rough concrete and stone. The new Peerless motor does the job to perfection.

This is one of hundreds of motor problems solved by Peerless engineers working with OEM engineers. Let's put our heads together and solve your motor problem. Write us today. We'll help you design or select the Peerless Electric motor that operates your equipment best.



ELECTRIC MOTOR DIVISION

THE PEERLESS ELECTRIC COMPANY

FANS · BLOWERS · MOTORS · ELECTRONIC EQUIPMENT

1509 W. MARKET ST. · WARREN, OHIO

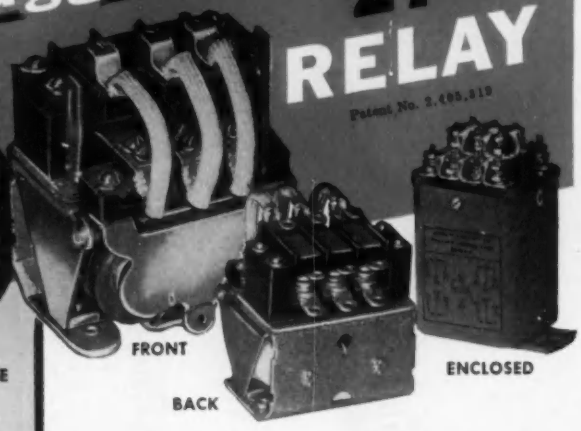
The Power Peerless Electric that Builds Reputations

Where **SHOCK** *and* **VIBRATION** *are a Problem . . .*

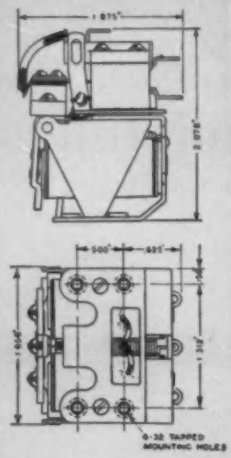
ENGINEERS CHOOSE the rugged *Phil-trol* 27 RELAY

Patent No. 2,695,919

For AVIATION and ELECTRONIC INDUSTRIES



TYPE 27QA—3 POLE

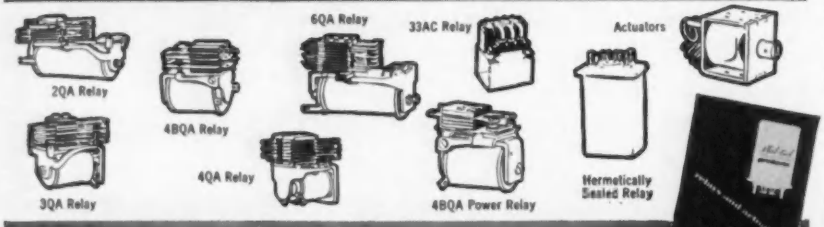


Phil-trol Type 27 Relays are available in 1, 2, 3, 4 or 5 pole, single or double throw. Operating voltage up to 230 D.C., resistance up to 13,400 ohms, minimum operating current is .001 amps. Available enclosed in dust cover or hermetically sealed.

■ Proved performance of Phil-trol 27 Relays in many vitally important applications has built great demand for this sturdy, sensitive and highly efficient relay. For instance, they are used for: propeller pitch control . . . cabin pressure and temperature control . . . guided missiles . . . computers . . . communication equipment . . . and many other electronic devices.

Phil-trol 27 Relays have unusual features like two-coil construction, which allows greater operating force for a given power input, and also completely eliminates magnetizing force losses at the armature hinge. The rigid frame and balanced armature design provides stability under conditions of high acceleration, severe vibration or shock.

For complete details on all of the many Phil-trol Relays available, write for the new Catalog shown below.



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PHILLIPS CONTROL CORP., Dpt. PE, Joliet, Ill.
Please send me a free copy of the new Phil-trol Relay and Actuator Catalog. Also, please arrange to have a Phil-trol Sales Engineer call on me.

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Street_____
City_____ Zone____ State_____

is available. Custom seals are fabricated for special requirements. The new seals can be inside diameter, outside diameter or butt seals. Various metals are used to meet the requirements of different environments. Advanced Vacuum Product Inc. 18-22 Liberty St., Stamford, Conn.

For more information—
Circle 58, inside back cover

Voltmeter With 0.25 Per cent Accuracy

This a-c voltmeter has both scale expansion and recording over the 100-500 range. It covers the range in 39 easy-to-read steps, full scale. Frequency response is uniform between 50 and 2000 cycles, eliminating the need for delicate or specially built laboratory voltmeters to measure a-c voltage accurately.

The voltmeter offers built-in recorder connections for continuous recording of line voltage fluctuations with a 1 microampere d-c recorder, simplifying problems of voltage regulation or stabilization in a-c systems. Beckman Instruments, Inc., 1432 Nevin Ave., Richmond, Calif.

For more information—
Circle 59, inside back cover

Illuminated Digital Voltmeter

The dial of this voltmeter is equipped with an illuminated, automatic decimal point and polarity sign as an aid to quick, accurate readings. Sensitivity ranges for the Model 615 are from 1 millivolt to 1,000 v and from 1 k to 10 meg, with an accuracy rating of 1 per cent (on dc and ohm, 2 per cent on ac). Hycon Mfg. Co., 2961 E. Colorado St., Pasadena, Calif.

For more information—
Circle 60, inside back cover

Totally Enclosed Dial-Type Rheostat

The hand operated Model D-40 rheostat, rated at 9 amp, 115 v, ac-dc, 75 to 300 ohm, in continuous service, allows step control for low-current applications in electronic, industrial, aeronautical and consumer equipment.

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Spacemaker

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- ★ OIL pressure to 750—AIR to 200 P.S.I.
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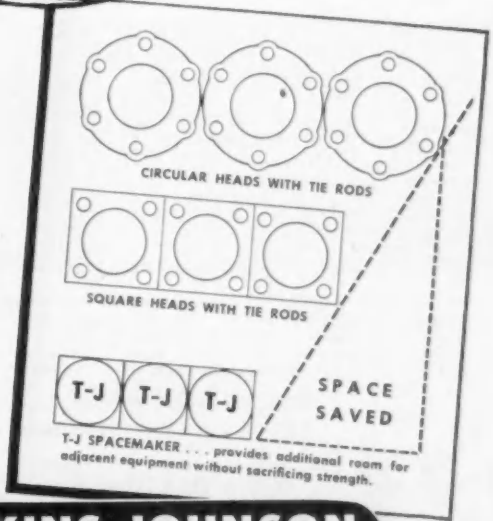
- ★ Hard Chrome Plated Bodies and Piston Rods

Compare feature by feature—you'll see why T-J Spacemaker Cylinders are today's top choice for streamlined power movement in automation! The only cylinder with all the extras as standard. Write for bulletin SM-454-2, The Tomkins-Johnson Co., Jackson, Mich.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T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

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RIVITORS . . AIR AND HYDRAULIC CYLINDERS . . CUTTERS . . CLINCHORS

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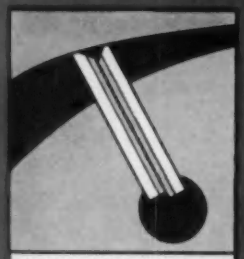
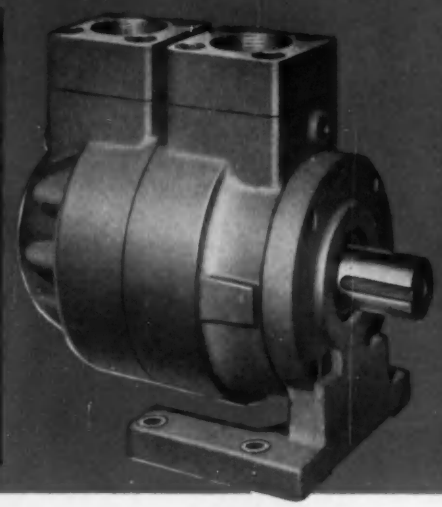


TWO VANES ARE BETTER THAN ONE

The hydraulically balanced DUAL-VANES in DUDCO Fluid Motors, as contrasted with conventional designs, maintain MULTIPLE AREAS OF CONTACT ON THE CAM RING . . . doubling the number of effective barriers to slippage and power loss. This patented principle is an exclusive DUDCO feature!



DUDCO

FLUID MOTORS

Compact and sturdy, DUDCO DUAL-VANE Fluid Motors operate quietly and smoothly under the most strenuous conditions. They're built to "take it" . . . frequent reversals, rapid accelerations or stalling under load. With DUDCO you get the big advantage of 2000 psi operation at a cost comparable with that of lower pressure equipment.

DUDCO is a big, exciting story for every hydraulics engineer because . . . power losses are minimized and operating efficiency is higher . . . starting torques are high . . . operation is smooth, quiet and exceptionally free from wear or maintenance problems.

On Conveyor systems for agricultural, food processing, mining and other industries, DUDCO DUAL-VANE Fluid Motors provide the extras in performance that save time, money and labor. Operating

the winches on a giant tank retriever and other large mobile equipment calls for high starting torque and the dependable power of DUDCO DUAL-VANE MOTORS.

Write for Bulletin DM-301 fully describing DUDCO DUAL-VANE Fluid Motors today!

DUDCO DIVISION

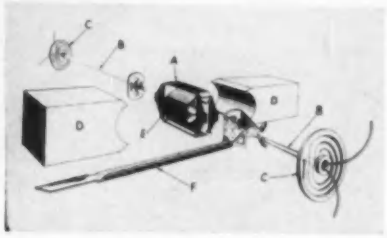
THE NEW YORK AIR BRAKE COMPANY

1712 EAST NINE MILE ROAD • HAZEL PARK • MICH.

An integral switch turns the unit off automatically when the pointer dial is turned to "off." The dial allows selection of 40 different resistances.

Measuring 3⅛ × 2⅞ in. wide, the die-cast aluminum case is mounted on rubber pads for table-top operation. The core is molded of highest quality ceramic materials and is continuously wound with special alloy resistance wire held permanently secure for dependability and long life. Colbert Die Cast Co., 5416 Tweedy Blvd., South Gate, Calif.

For more information—
Circle 61, inside back cover



Suspension-type Meter Movement

The armature in this meter movement is held in place by fine bifilar wires that are kept under precise tension by disc springs contained in the adjustable end pieces of the movement cartridge. Friction inherent in common pivot and jewel construction is eliminated by the unique bifilar suspension principle. This is reported to provide a far more rugged meter movement than generally associated with instruments of laboratory accuracy. Laboratory standards constructed to this principle have been shock tested to 500 G without appreciable loss of accuracy.

The new meter movement will be supplied in custom-built meters and high precision, high shock laboratory instruments. Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

For more information—
Circle 62, inside back cover

Bourdon Pressure Gage

When used with this manufacturer's load cells, this 19½ in. gage is said to provide guaranteed accuracy of ± 2 per cent of load range. Its exclusive bifocal pointer and high visibility dial permit simplified reading from a

distance or close to the indicator. The dial scales of the new indicators are individually calibrated at twenty different points to insure uniformity and accuracy. Pointer "zero-ing" is accomplished with a special locking knob that provides stable zero settings over 20 per cent of the dial range.

The new indicator, with an equivalent linear length of 55 in., is finished in white with black graduations. A clear, non-crazing plastic dial covering is mounted in a chrome bezel.

These indicators are available in a wide variety of ranges to 100,000 lb capacity. Models can also be supplied with special scales, top center dials and other modifications to meet special applications. A. H. Emery Co., New Canaan, Conn.

For more information—
Circle 63, inside back cover

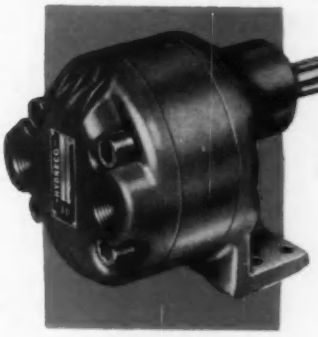
High Voltage Capacitor

This high voltage capacitor is of extremely small size and light weight. A "high-breakdown" plastic film is being employed to produce capacitors remarkably smaller and lighter than previously available. These capacitors operate at temperatures to 125 C, with voltages from 2 to 60 kv. They are available with hermetic glass or plastic tube housings with wire leads or threaded stud mountings. Film Capacitors, Inc., 3400 Park Ave., New York, N. Y.

For more information—
Circle 64, inside back cover

Surface Thermometer For Up to 750°F

The instrument is designed for the fast and accurate checking of the surface temperatures of hot plates, platens, die casting dies, rubber molds, plastic molds and all surfaces where the temperature has a range from 50 F to 750 F. The heat- sensitive element in this thermometer consists of a bimetal spiral which has



These famous Gear Type Motors operate with pressures up to 1500 psi. Available in flange or foot-mounted models, in a complete range of sizes to 52 hp. They feature the exclusive HYDRECO Four Bolt design which places greatest strength in the area of greatest pressure.

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FLUID MOTORS

You find the answers to so many problems in the wide experience of HYDRECO engineers . . . especially where a function involves rotary motion. Powering the sweeper or the snow blower on municipal equipment, driving conveyor belts on trenchers, or shaking walnuts out of the trees at harvest time . . . these are but a few of hundreds of money-saving operations HYDRECO Fluid Motors are called upon to perform.

HYDRECO Fluid Motors, with their high starting torque, instant reversibility, and capacity for handling rugged and seemingly impossible assignments, are the natural choice of design engineers. HYDRECO dependability stems from the fundamentally sound "Pressure-Balanced" design, unmatched craftsmanship and the "know-how" of thousands of outstanding hydraulic applications.

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been aged and accurately calibrated for maximum stability.

The spiral is closely coupled to the heated surface to be measured and the thermometer is affixed to the surface by means of two magnets. The two magnets are incorporated within the thermometer base and the bimetal receptacle itself becomes an integral part of the magnetic circuit, thereby assuring an intimate and powerful contact. The thermometer reaches stability within three minutes. Total weight is less than 2 oz. Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif.

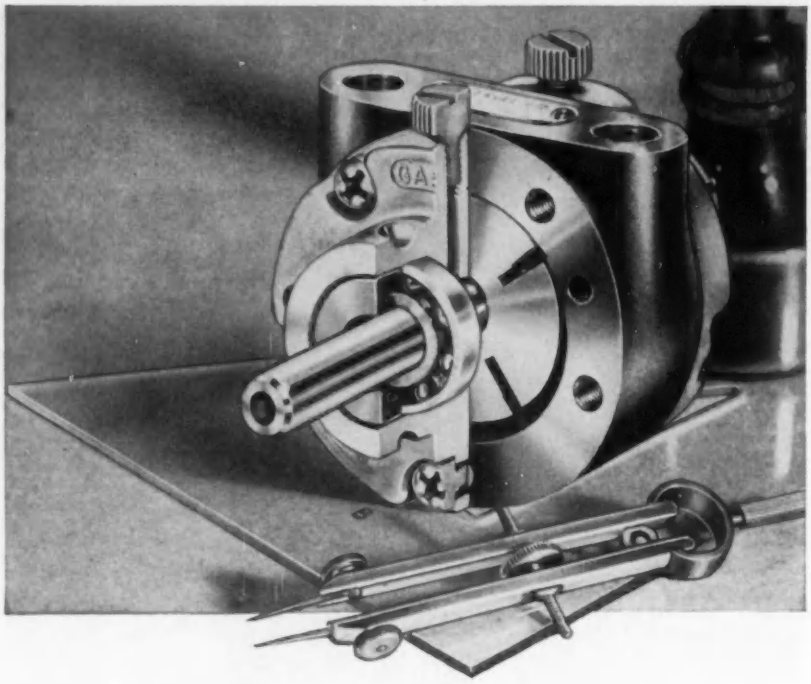
For more information—
Circle 65, inside back cover

Differential Pressure Transducer

This transducer is intended for the measurement of pressure in ranges from ± 200 to ± 5000 psi differential at line pressures up to 500 psi. The instrument in indicated for both static and dynamic measurements and will withstand overloads up to 100 per cent of the rated range. The dynamic response permits measurement of transient pressure phenomena involving high frequency components. The natural frequency extends from 2000 cycle per sec at the lowest range to 10,000 cycle per sec at the highest.

The Model DP-15 was designed for rocket and jet engine testing, where the close mechanical coupling required for high frequency response may introduce extreme mechanical excitation. The instrument may be used as well in laboratory measurement and industrial control applications with indicating, recording and control systems, adapted to operation with variable reluctance type transducers.

The construction, by this maker, in common with other high pressure transducers, features a pressure sensing diaphragm integral with stainless steel body. The natural frequency is determined only by the diaphragm; there are no additional elements to lower the natural frequency or to produce spurious modes of vibration. The electrical pick-off elements are potted with epoxy resin in plugs which are imbedded in the body. The weight is 12 oz. Any excitation frequency from 60 to 20,000 cycles per sec may be used; at 3000 cycles per sec the max-



All Gast rotary air motors, compressors, vacuum pumps are designed on this

SIMPLE PRINCIPLE

Rotary Air Motors 1/20 to 4 h.p.

Air Compressors to 30 p.s.i. to 24 c.f.m.

Vacuum Pumps to 28 in. to 24 c.f.m.

Always striving for simplicity in products you design? So are we. Simplicity pays — in lower costs and greater dependability. And it's a *big* reason why engineers favor Gast components . . . and why users get years of satisfactory service.

All Gast Units incorporate this simple, rotary-vane principle: A rotor and four sliding vanes are the only moving parts. Centrifugal force holds self-seating vanes tightly against the precision-ground interior surface of housing, maintaining a continuous seal, and taking up any wear automatically. Usually of composition material, vanes may be carbon (for oil-less models) or aluminum. Air delivery is positive, pulseless, quiet.

There are *no* piston rings, *no* heavy hinged parts, *no* rockers, etc., to wear out, require adjustment or add dead weight. *No* bulky air tanks, either.

So get the advantages of Gast simplicity for *your* products! *Write for new "Application Ideas" Booklet — and request data on models that interest you.* Gast Manufacturing Corp., P.O. Box 117-V Benton Harbor, Michigan.

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GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

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Here's How

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Helps Give

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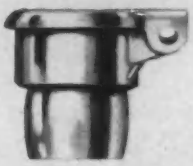
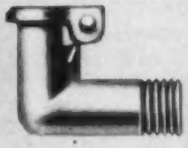


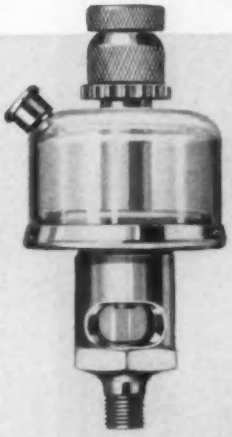
OIL HOLE COVERS

This model is designed to fit into a simple drilled hole. Ideal for use on small motors, generators, starters and light machinery—for dependable oil hole protection at moderate cost. Larger sizes frequently used as filler caps on tanks or reservoirs. Style R—No. 305.



OIL CUPS

Accurately machined from a solid brass one-piece forging, this oil cup permits safe, dependable application of lubricant at very low cost. Used widely on motors and small machinery requiring side oiling. Style L—No. 1202.



SIGHT GRAVITY FEED OILERS

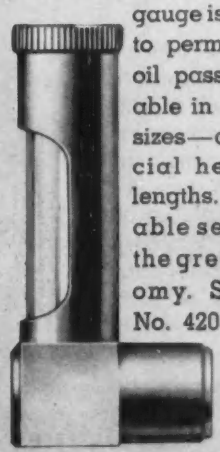
Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

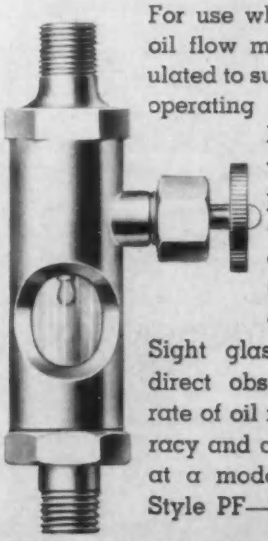
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

FORGED BRASS GAUGES

Heavily constructed in a single piece from forged brass — this gauge is also drilled to permit generous oil passage. Available in many stock sizes—and in special heights and lengths. For dependable service with the greatest economy. Style FG—No. 4204.



SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

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imum input voltage is 30 v and the full scale output is 40 millivolts per volt input in bridge circuit operation. All instruments are temperature compensated for sensitivity and zero shift between −65 F and 250 F. The rated accuracy including linearity is 1 per cent full scale or better. North American Instruments, Inc., 2420 N. Lake Ave., Altadena, Calif.

For more information—
Circle 66, inside back cover

Linear Displacement Transducer

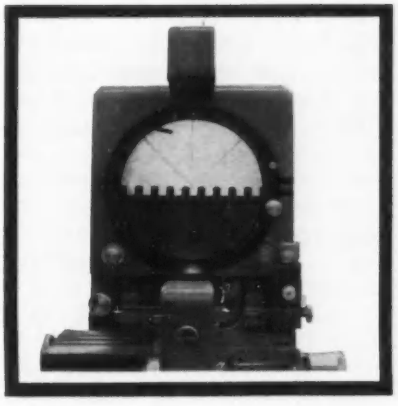
This transducer is a variable-reluctance pickup for converting linear motion into an electrical output. The unit is assertedly designed to be completely free from changes in scale factor with variations in frequency, excitation voltage and temperature over wide ranges of these parameters. The Model 154 consists basically of two coils in a magnetic circuit whose configuration allows an armature shaft to vary the reluctance of the two coils when displaced—yet the inductance is only a function of armature position due to the character of the magnetic circuit. The relative shaft of inductance is manifested through a simple bridge circuit as an output voltage which in many applications proves high enough to preclude intermediate amplification. The amplitude of output voltage is a function of input voltage; input voltage ranges from 28 to 115 v. Output voltage is 3 v for 28 v input, 30 v for 115 v input. Useful temperature range is −65 to +165 F. General Cybernetics Corp., P. O. Box 987, Beverly Hills, Calif.

For more information—
Circle 67, inside back cover

Weight, Force or Stress Transducers

Static or dynamic load values are transmitted by these transducers, available in ranges from 500 to 50,000 lb. Based on the differential transformer principle for measuring minute displacements of an iron core in an inductive field, the transducers provide 1 per cent linearity, a frequency range from zero to 1000 cycles per sec, and exceptional stability of calibration and zero point. Temperature

Saved . . . 296 pieces per thousand!



Like many another manufacturer, the Hoover Company, Canton, Ohio, has its rejection problems. A typical one involved a flexible, rubber-like "litter picker" used in its vacuum cleaners. Although tolerances ranged from .085″ to .101″, rejects ran as high as 30%.

To solve this problem, Hoover employed a Kodak Contour Projector to measure the parts, plotted results in accordance with modern methods of statistical quality control. Based on these studies, alterations were made in the cutting tool and the holding fixture for the part. Rejects dropped from 30% to less than ¼ of 1%. Savings amounted to 296 pieces per thousand.

"Optical gaging with the Kodak Contour Projector," say Hoover engineers, *"eliminated incorrect readings caused by mechanical distortion of the parts. In addition, optical methods of measurement proved from 4 to 5 times faster than conventional gaging techniques."*

Your own production measurement or inspection problem may similarly be solved by optical gaging with a Kodak Contour Projector. To find out more about it, send the coupon for your copy of "The Kodak Contour Projector."

the KODAK CONTOUR PROJECTOR

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Special Products Sales Division, Rochester 4, N. Y.

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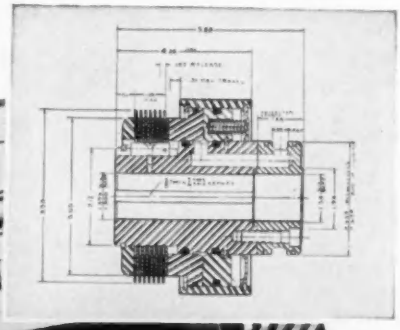
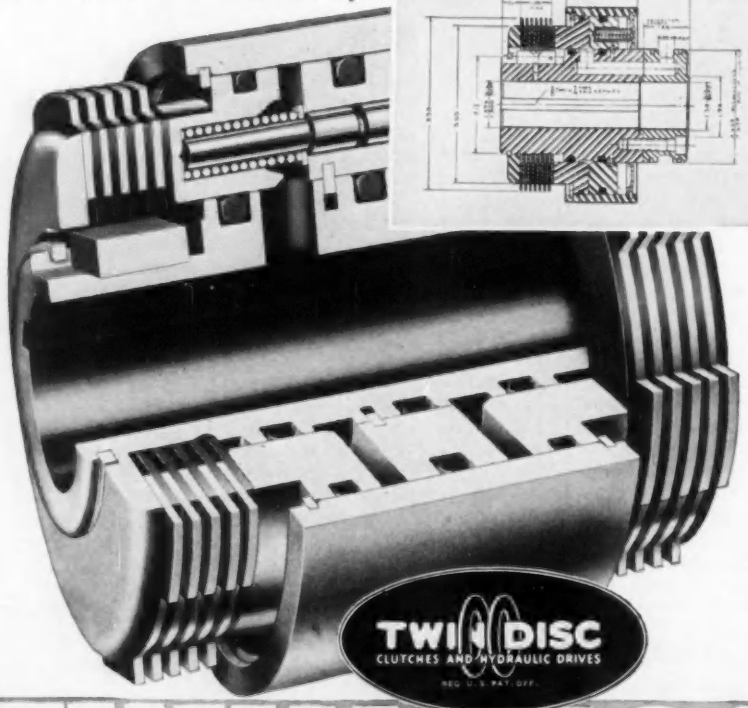
Superior control, lower costs...

CONSIDER the *outstanding* advantages you will gain by designing Twin Disc Oil-Actuated Multiple Plate Clutches into your machines: 1 You'll *eliminate entirely* the need for clutch adjustment, and maintain *constant torque.* The integral oil cylinder acts as a floating pressure plate, *automatically increasing in travel as the plate stack wears.* The torque value *cannot* decrease . . . there is *no* chance for an inexperienced operator to "burn up" the clutch. 2 With *high, constant* torque capacity, it is often possible to use a *smaller* size clutch—permitting more *compact* installations. 3 You'll have *ready adaptability to remote control,* eliminating complicated actuating linkage. 4 You'll benefit from *consistently longer wear-life,* since there is no possibility of plate slippage.

Write to Twin Disc Clutch Company, Racine, Wisconsin, for *complete* information.

Blueprint of Model MOS (single) and cutaway view of Model MOD (duplex) show interlocked pistons of Twin Disc Oil-Actuated Multiple Plate Clutch. Write for latest Bulletin No. 305.





TWIN DISC

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

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error and hysteresis are negligible. Transmitted values can be measured with an accuracy stated to be better than 1 per cent and indicated, recorded, or used for control functions using associated equipment. Daytronic Corp., 216 S. Main St., Dayton 2, Ohio.

For more information—
Circle 68, inside back cover

Air Flow Differential Pressure Transducer

The pressure response movements of each of two metal bellows is translated into motion of sliders of paired precision potentiometers. One bellows is connected to the dynamic pick-up line from pitot or venturi; the other bellows is exposed to pressure from the pick-up line sampling the static or ambient pressure. The electrical outputs of each of the instrument's four potentiometers are individually brought out to terminals, providing individual access to dynamic or to static data. Through an external electrical combining network, dynamic data may be automatically "normalized" or corrected with respect to static data as required by the application, limited only by the designer's ingenuity. Typical application to speed-altitude measurement provides a range from 0 to 580 knots over an altitude range of −1000 to 20,000 ft. Potentiometer resistance ratio vs. pressures is linear within 0.5 per cent; hysteresis within 0.5 per cent; change with temperature (−55 C to 71C) not over 0.5 per cent; resolution increment less than 0.2 per cent of pressure range. Construction withstands 40 g shock. Size $2\frac{7}{8} \times 4\frac{3}{8} \times 5\frac{7}{8}$ in.; weight, 1.3 lb. Technology Instrument Corp., Acton, Mass.

For more information—
Circle 69, inside back cover

Indicator for Differential Transformer Transducers

Force, displacement, pressure, stress, strain, flow, weight, size or any other mechanical quantity that can be measured by means of differential transformer transducers, can be indicated, recorded or used for automatic alarm or control purposes using Model 300 displacement indicator. The unit in-

dicates the value of the measured quantity on an illuminated 4½ in. panel meter.

The amplifier circuit provides a basic sensitivity of one millionth of an inch using a typical differential transformer transducer. Drift is less than 1 per cent in 4 hr and may be readily compensated. Overall linearity is better than 1 per cent and repeatability of measurement is better than ½ per cent. Weight is 16 lb. Daytronic Corp., 216 S. Main St., Dayton, Ohio.

For more information—
Circle 70, inside back cover

Pressure Pickup Has Piezoelectric Sensing Element

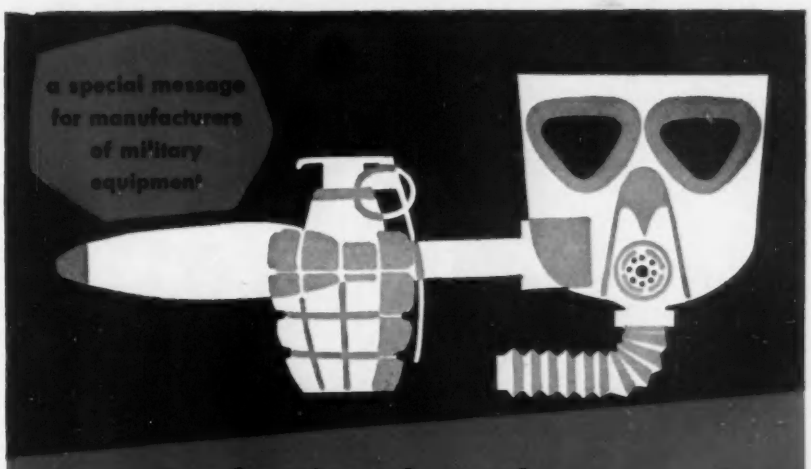
The piezoelectric ceramic element eliminates the requirement for external power and permits the use of cables up to several hundred feet long, thereby greatly simplifying the instrumentation system. Further simplification is made possible by the external design which permits direct flush mounting.

The Model 2501 is presently available in 3 ranges: 0 to 500 psi, 0 to 1000 psi and 0 to 2500 psi. Full scale output for each of these ranges is in excess of 15 v. The natural frequency ranges upward from 35 kc, permitting the measurement of rise times of the order of 10 microseconds. Because of the rigid mechanical construction, the effects of vibration are negligible, amounting to less than 0.007 per cent of full scale per "g" for all units. Endevco, Dept. P, 180 E. California St., Pasadena, Calif.

For more information—
Circle 71, inside back cover

Concentric, High Ratio Air Capacitors

Electrically, these capacitors have a voltage breakdown point of over 750 v, dc, and a high degree of stability. The Type 1800 capacitor has a minimum of 0.4 mmf and a maximum of 12 mmf. The Type 1900 capacitor has a minimum of 0.6 mmf and a maximum of 30 mmf. These capacitors are miniature in size. They feature an improved stop and double-spring fingers which give a high degree of stability and eliminate backlash. The materials



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AMS-2402A USA-50-80-11A J.Q.D. No. 144B
USA 57-93-2A O.S. No. 1374 USA 57-0-2C AN-P61
A-XS-1607 QQ-P-416 QQ-Z-325 MIL-3151 —
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ON ZINC AND CADMIUM you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.

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ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

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WINSMITH SPEED REDUCERS

The all-new "C" Line Speed Reducers by Winsmith offer a host of improved features that simplify your design problems and result in improved performance for your equipment.

By achieving *greater* horsepower and torque output in *less space* "C" Line Speed Reducers allow you to specify smaller units to meet output requirements.

And, this new line furthers the reputation of your equipment thru more rugged performance and dependability.

"C" Line Speed Reducers are available for immediate shipment in 5 sizes within the 1/100 to 5 hp range in a ratio range of 5:1 to 77:1. These 5 sizes are available in each of the models illustrated above. Nine additional sizes available soon. For complete design data on these first 5 sizes request Bulletin CHW-654. Watch for details on our new catalog on the complete "C" line.

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Springville, (Erie County) N.Y.

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INCREASED RATED HORSEPOWER AND TORQUE OUTPUT
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Larger, stronger shafts equipped with tapered roller bearings to provide greater capacity and ruggedness.

LONG SERVICE ASSURED
Special nickel phosphor bronze used exclusively in Winsmith Speed Reducers has greater nickel content than bronzes commonly used for gears. It has the greatest strength of all the phosphor bronzes.

ECONOMY
Compare the greater value per horsepower dollar of Winsmith "C" Line Speed Reducers with competitive lines.

used in these capacitors are silver-plated brass and Pyrex glass. The contact surfaces of the rotor are rhodium plated for smooth action. These capacitors also are available with Invar construction to provide lower temperature coefficient of capacitance. Johanson Mfg. Corp., Boonton, N. J.

For more information—
Circle 72, inside back cover

Subminiature Cable For Transducers

Since this coaxial cable was developed particularly for use with transducers in the field of shock and vibration, it is flexible and consequently not easily damaged. It has been treated to reduce self-noise generation to a minimum. It has a low capacity of 38 mmf per ft. It is usually equipped with a subminiature coaxial screw-type connector. The overall diameter of the cable is 0.017 in.

This cable may also be used for rf work having a characteristic impedance of 40 ohm and an insulation strength of 1200 v, dc. Gulton Mfg. Corp., Metuchen, N. J.

For more information—
Circle 73, inside back cover

Modular Bobbinless Resistors

A line of flat, rectangular, bobbinless non-inductive wire resistors of modular construction are said to eliminate waste area, as in a round object. The rectangular construction is said to occupy minimum space. This construction also permits more rapid heat dissipation because the resistor may be laid flat on a metal chassis. Other fully insulated components may be built or stacked over the resistor.

The resistor is laminated in glass fiber and embedded epoxy or polyester resins. Excellent heat distribution and dissipation is achieved by low pressure laminating. All ½ w units have a hotspot temperature of less than 185 F at twice the rated wattage. Temperature rise for these same units is 25 C. They may be used for temperatures of −60 C to 150 C. Resistance ranges of 1/10 ohm to 2½ megohm or higher are available. Thickness is from ⅛ in. up.

For all high value precision resistors,

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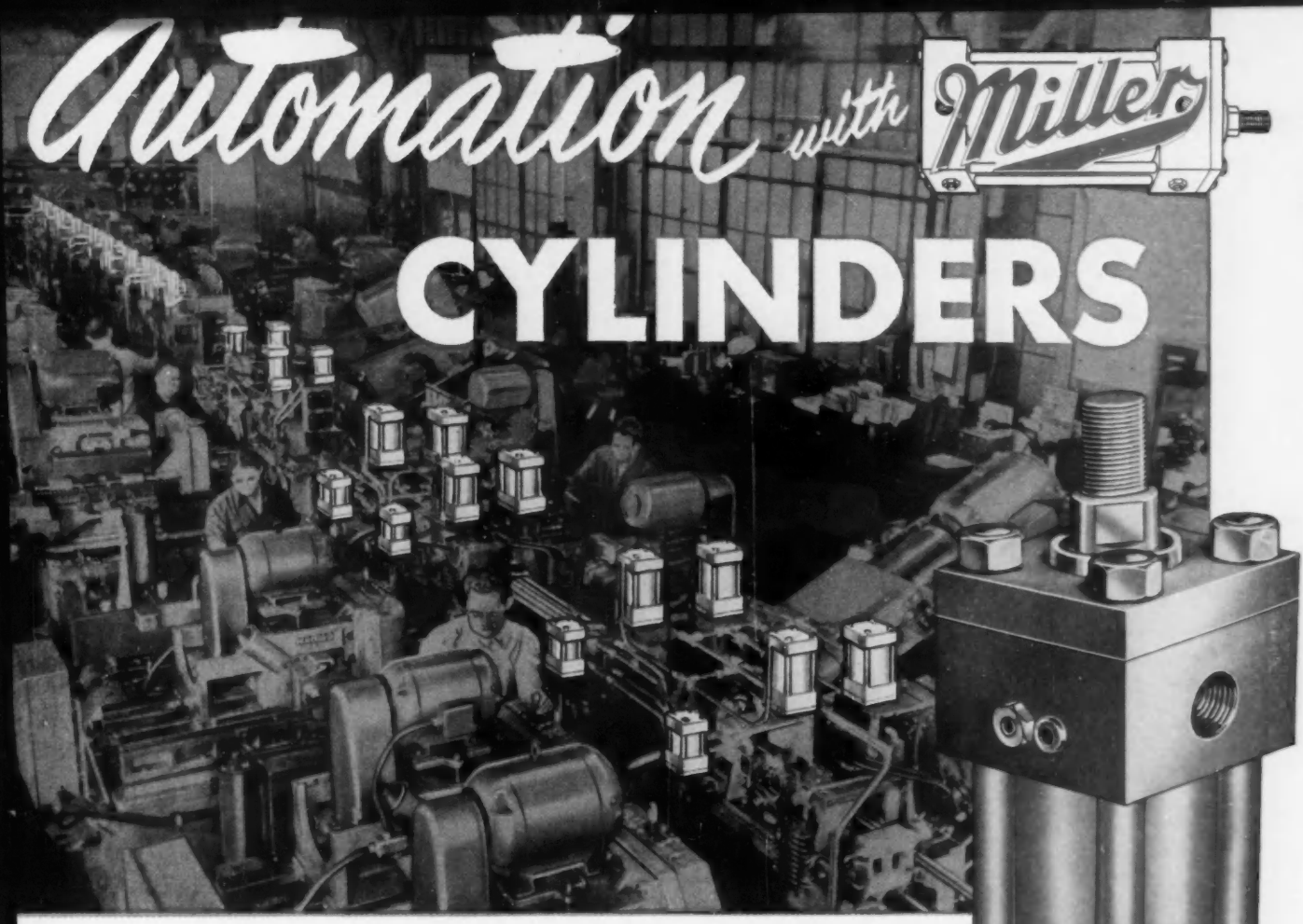

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The production magic of "AUTOMATION" demands faultless performance—as the failure of one important component of "automation" machinery and equipment can shut down an entire manufacturing process.

In the "automation" application illustrated above, 22 Standard Miller High Pressure Hydraulic Cylinders are employed on each of two identical automotive transfer machines built by Ex-Cell-O Corp. of Detroit, Michigan, a recognized leader in the design and manufacture of "automation" equipment.

The machines perform—simultaneously and automatically—drilling, countersinking, counterboring, and tapping operations on automotive cylinder heads. And the Miller Cylinders accomplish the vital clamping, feeding, holding, rotating and locating operations that enable the machines to function as smooth "automation" production units.

Miller Cylinders are ideal for such "automation" applications. They withstand severest shock loads, provide millions of smooth strokes without repacking of seals or other maintenance. Their space-saving square design cuts installation and designing costs. They're available in an infinite variety of versatile power and stroke units that cover every need and permit the most economical choice for the application. And they fully meet the J.I.C. Standards.

Consult our engineering department or local representative. And write for complete information on this and other interesting applications and for our FREE Cylinder Bulletins A-105 and H-104.

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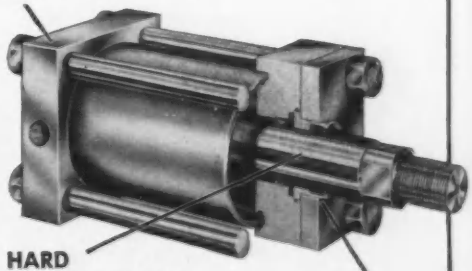

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special alloy wire with a temperature coefficient of resistance of 0.002 per cent per deg C is used. For low values resistors, other alloy wires with comparable temperature coefficients of resistance are used. Terminals consist of 1½ in. lead wires of soft drawn No 20 and 22 tinned copper wire, soldered or welded to the resistance elements. A wide variety of sizes is available. Monson Mfg. Corp., 6059 W. Belmont Ave., Chicago 34, Ill.

For more information—
Circle 74, inside back cover

Adjustable Capacitors

These capacitors may be adjusted to values from 1 percent below to 1 percent above nominal. Once set, the capacitance is said to remain constant indefinitely. In contrast with other types of adjustable capacitors, these employ a self-rigid type of winding which is inherently stable with external pressure. The extra pressure necessary to adjust the capacitor is a small fraction of the total pressure in the assembly, assuring an extremely high capacitance stability. The winding is completely non-inductive, minimizing power factor and soakage. Units are available in all capacity values from 0.01 mf to 1.0 mf. Rated working voltage is 200 v, dc. Film Capacitors, Inc., 3400 Park Ave., New York 56, N. Y.

For more information—
Circle 75, inside back cover

High Gain Magnetic Amplifier

The manufacturer states that for the first time in a magnetic amplifier, the speed of response has been made independent of the number of stages of amplification. In this three-stage amplifier the input and output phase occur during the same half cycle of the power supply. Reduction of the series major loop lag permits the use of more negative feedback in the inner loop, resulting in improved stability.

These magnetic amplifiers can be used either as phase reversible a-c amplifiers or as polarity reversible d-c amplifiers for d-c inputs with no changes in the internal wiring of the amplifier. Model 504-1 has a power

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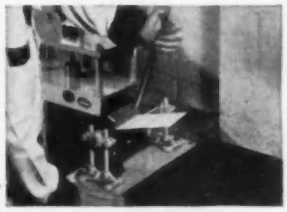
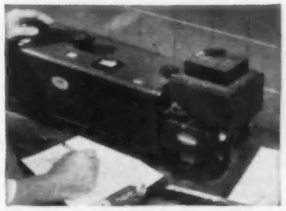
Service and technical service are an integral part of Glidden relations with all users of Nubelite.



Conical mandril bending test proves NUBELITE's high film strength and flexibility.



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output of 15 w, ac, phase reversible with a-c input. On dc, this is also 15 w, polarity reversible with d-c in put. For use with power supply of 115v, 60 cycle, ±10 percent. Weight: 10 lb. Dimensions: 6 x 5 x 10½ in. Librascope, Inc., 808 Western Ave., Glendale, Calif.

For more information— Circle 76, inside back cover

Metal Film Resistor

The noble metal resistive element of the Series 850 resistors is deposited on the inner surface of a glass tube. Electrical connections are silver bands fused to the element and the glass. End caps are bonded to the glass in a glass-to-metal seal, providing hermetic sealing for over 60 psi. Various resistances are obtained by varying the metal deposit in solid form, spirals or parallel bands between the end caps. Because the metal deposit is inside, there are no protective coatings used that tend to break down or change performance qualities.

Performance characteristics exceed the requirements of Mil-R-10509A. Accuracies of ±1, ±2 and ±½ per cent are possible in production quantities.

These resistors are now available in ½, 1 and 2 w sizes. The ½ w model is available in values from 4 to 100,000 ohm; the 1 w, from 10 to 100,000 ohm; and the 2 w, from 10 to 200,000 ohm. Higher values will be available shortly. Daven Electronic Sales Corp., 191 Central Ave., Newark, N. J.

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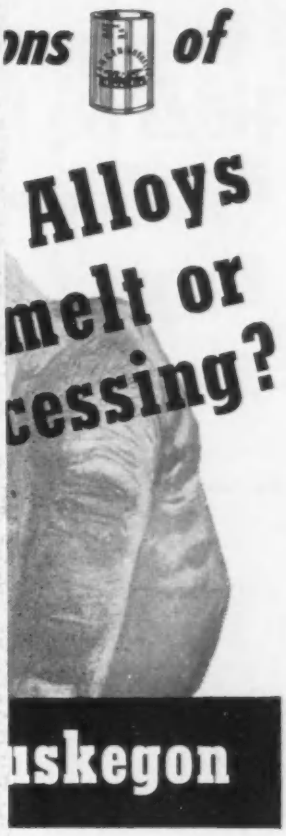
blower has a 3-in. tunnel and is rated at 70 cfm at 1 in. of static water pressure. This new blower weighs 20 oz and measures $3\frac{1}{8}$ x $3\frac{1}{2}$ x $3\frac{3}{8}$ in. Its design affords a large volume of cooling air with minimum external projection. Operating directly from a 115 v, 400 cycle line in conjunction with a phasing capacitor, this unit is designed to meet all applicable military environmental specifications. Servomechanisms, Inc., 625 Main St., Westbury, N. Y.

For more information—
Circle 80, inside back cover

Synchros of 1.437 in. Max Dia

These instruments are said to provide high accuracies for their size (1.437 x 1.640 in.) and weight (4.7 oz). These new synchrose are available with leads, or can be specially ordered with radial or axial terminals. Cast stator and clamped bearing race



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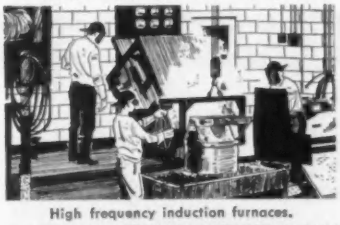
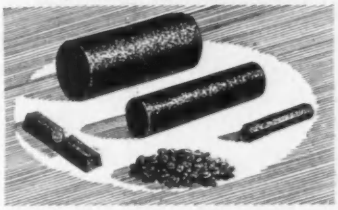


High frequency induction furnaces.



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shock-resistance are increased, permitting the resistors to reach operating temperature faster than conventional resistors. They are rated at 350 C hot-spot temperature. Shallcross Mfg. Co., Collingdale, Pa.

For more information—
Circle 78, inside back cover

Subminiature Preamplifier

This 6-oz unit has been constructed for coupling low level signal devices into standard metering and recording systems without introducing extraneous noise from vibration. It is $2\frac{11}{16}$ x $1\frac{5}{16}$ x $2\frac{1}{4}$. Power requirements are: filament, 6 or 28 v; plate, 105 to 250 v.

A four-tube unit, this device incorporates a cathode follower input to give an input impedance of 100 megohms. It has selective gains of 10, 30, 100, and frequency response from 5 to 20,000 cycles per sec. Gulton Mfg. Corp., Metuchen, N. J.

For more information—
Circle 79, inside back cover

Blower for Electronic Equipment

Developed for the cooling of airborne electronic equipment, this blower has a 3-in. tunnel and is rated at 70 cfm at 1 in. of static water pressure. This new blower weighs 20 oz and measures $3\frac{1}{8}$ x $3\frac{1}{2}$ x $3\frac{3}{8}$ in. Its design affords a large volume of cooling air with minimum external projection. Operating directly from a 115 v, 400 cycle line in conjunction with a phasing capacitor, this unit is designed to meet all applicable military environmental specifications. Servomechanisms, Inc., 625 Main St., Westbury, N. Y.

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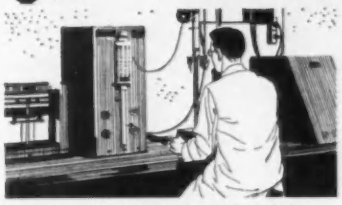

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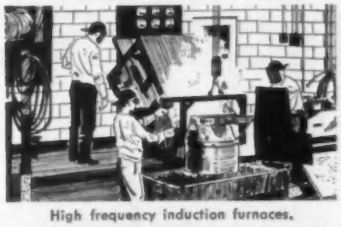

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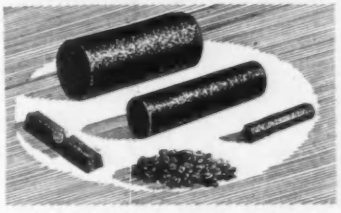

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PRODUCTION MELTS OR SAMPLE JOBS — A combination of test furnaces and larger multiple production furnaces assure completely flexible service at any time.

FAST ACTION ON YOUR ORDERS — No long delays for a mill run. Alloys delivered in drums, clearly marked with all specifications for fast selection and storage.

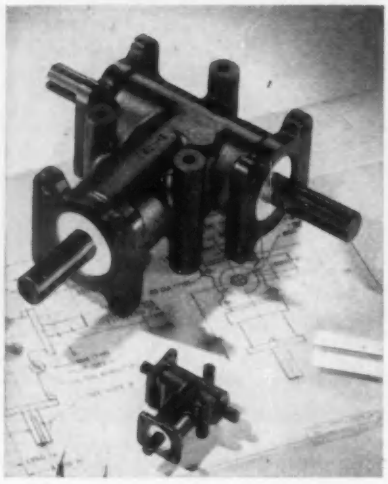
Write today for your copy of new MasterMet Alloy Bulletin for complete technical details.

Cannon Muskegon CORPORATION
MASTERMET
2877 Lincoln Street • Muskegon, Michigan
METALLURGICAL SPECIALISTS

Here's the NEW

2½ HP

ANGLgear TRADE MARK



Designers and engineers have been asking for this big right-angle drive. It's rated at 2½ hp at 1200 rpm, will transmit a maximum torque of 2500 lb. in.

This right-angle giant, Model 340, is a logical development of Airborne's smaller ANGLgear models. It has the same features that have made ANGLgear the most popular power takeoff in industry. ANGLgears are sold only through your local distributor. See our literature in the product design section of Sweet's Catalog.

AIRBORNE

Accessories Corporation

HILLSIDE 5, NEW JERSEY

construction insure lifetime alignment and accuracy. Dielectric insulation between windings and case is rated in excess of 550 v, ac. The following types are available: signal generators, receivers, regular and high impedance control transformers, high output control transformers, control differentials, regular and high impedance resolvers and sine-cosine generators. Clifton Precision Products Co., Inc., Maple at Broadway, Clifton Heights, Pa.

For more information—
Circle 81, inside back cover

Blower Will Move 525 Cfm Free Air

Designed and built to conform to applicable military specifications, this blower is equipped with a 7 in., five-bladed fan, and it operates at a speed of 3,400 rpm. Under the NEMA code, it will move 525 cfm, free air.

Motor case is totally enclosed. Weight is 5 lb. 10 oz. Required voltage is 115 v, ac, 60 cycle, single-phase and 0.4 amp. Mission-Western Engineers, Inc., 132 W. Colorado St., Pasadena 1, Calif.

For more information—
Circle 82, inside back cover

Miniature Silicon Junction Diodes

These devices are described as having high forward conductance combined with extremely high back resistance. In several of the diode types, this resistance is in the order of 10,000 megohms. In many applications, this is essentially an open circuit. This degree of back resistance makes it possible to use these silicon diodes in many entirely new applications, in addition to those now closed to germanium through temperature limitations.

Characteristics and specifications for the first eight types of a proposed comprehensive line of silicon junction diodes are now established. All of these types have an ambient operating temperature range of from −80 to 200 C. The new diodes are fusion-sealed in a one-piece glass body, impervious to moisture. Envelope is externally coated with black silicone enamel to shield crystal from light. Dimensions, glass body: 0.265 by 0.103 in. max. Hughes Aircraft Co., Florence Ave., at Teale St., Culver City, Calif.

For more information—
Circle 83, inside back cover

HYDRAULICS AND PNEUMATICS

Cylinders With Integral Valves

These cylinders have their valves in the rear head and are available in 2 and 3 in. bores, any length of stroke up to 60 in. and with or without adjustable cushions. Ground and polished stainless steel rods, honed brass tubes and nylon-lined bearings are used. The built-in valves are of the slider type. This slider is actuated by a spool whose instantaneous motion is achieved by momentarily bleeding air from one end of it or the other.

On Model SVE, the actuation of the cylinder is accomplished thru two solenoids available for either 110 or 8 v operation. On Model SVA, the actuation is achieved thru two bleeder valves.

The valves have large ports throughout for fast actuation and two built-in speed controls. The solenoid coils are embedded in any epoxy resin. A choice of foot mounts, flange mounts, swivel brackets and rod clevis is available for mounting cylinders in any position. A. K. Allen Co., 57 Meserole Ave., Brooklyn 22, N. Y.

For more information—
Circle 84, inside back cover

Operates On Oil or Water With Same Parts

This cylinder can be operated on 500 psi max oil or water service, or 200 psi on air, without interchanging or adding parts. Bore diameters available are: 1¼, 2¼, 3, 4 in.

The new cylinder has a stainless steel piston which is ground and polished to give the rod seal, bearing and

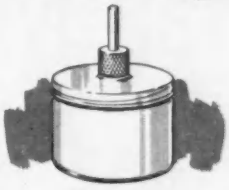
You name it-MOYNO® pumps it!

Foods

Potato salad, chow mein, peas, cream-style corn, tomatoes, molasses, chocolate.

Chemicals

Caustics, acids, dyes, petroleum solvents, soaps, sludges, latex, synthetic resins.



Pastes

Paper coating, starch, seam paste, size, adhesive dope, heavy grease, graphite sludge.

Abrasives

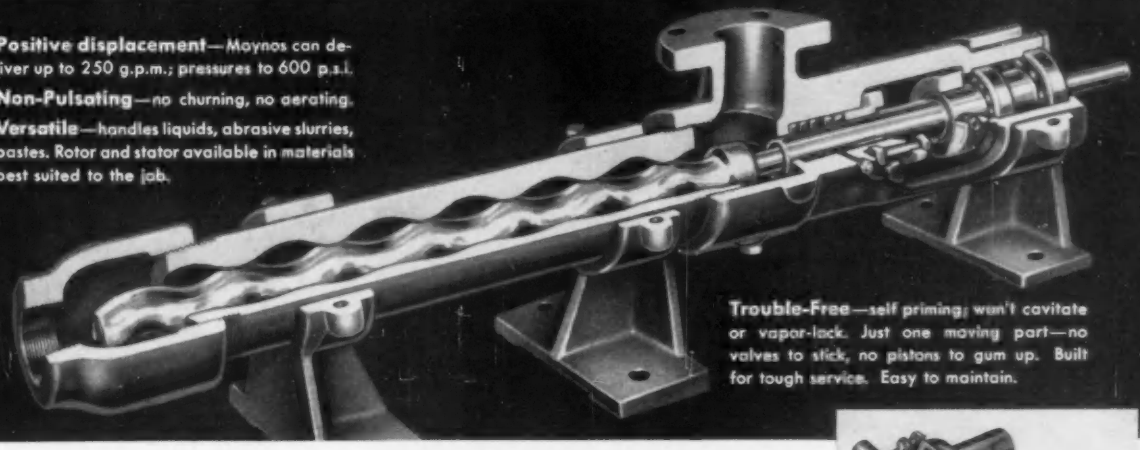
Insulator clay, frit, ground glass and water, porcelain glaze and enamel, cement, plaster.

FEATURES OF THE MOYNO THAT MAY SOLVE YOUR MATERIALS-HANDLING PROBLEM

Positive displacement—Moynos can deliver up to 250 g.p.m.; pressures to 600 p.s.i.

Non-Pulsating—no churning, no aerating.

Versatile—handles liquids, abrasive slurries, pastes. Rotor and stator available in materials best suited to the job.



Trouble-Free—self priming; won't cavitate or vapor-lock. Just one moving part—no valves to stick, no pistons to gum up. Built for tough service. Easy to maintain.

R & M Moynos handle almost anything that can pass through a pipe

The Moyno is a problem-solving pump. And whether your problem is one of materials, maintenance or flow, there's a better-than-even chance that the Moyno is the pump you're looking for.

Here is a completely different kind of pump that handles almost anything that will push through a pipe, from free-flowing liquids to non-pourable pastes—even materials containing relatively large particles or abrasives.

This is how the Moyno works: a screw-like rotor turning within a double-threaded stator creates cavities which *progress* toward the discharge end of the pump, carrying the material being handled. The result is a smooth, steady flow, free from pulsation and turbulence.

The pumping elements of the Moyno are available in a wide range of materials, depending upon the substances to be pumped. From stainless steels and synthetic rubber to tool steels, bronze, plastics—there is a Moyno that will do the job you want, and do it with remarkable efficiency.

Industrial-type Moynos are available with capacities to 250 g.p.m.; pressures to 600 p.s.i. Small Moynos (see inset), used as original equipment, serve on washers, water pumps, sprayers, and many other products.

FREE...

this informative bulletin

Tell us your pumping problem—let's see how the Moyno can help solve it. If necessary, we'll be glad to run tests for you in our own laboratories. In any case, get the details on the Moyno—mail the coupon below.

R&M

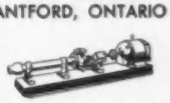
ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Fractional and Integral HP Motors

Desk, Window, and Household Fans

Hoists and Cranes



Moyno Pumps

Propellair Industrial Ventilating Equipment

Robbins & Myers, Inc.
Pump Division, Springfield, Ohio (PD)

Please send Bulletin 30C on Moyno Pumps

Name _____ Title _____

Company _____

Address _____

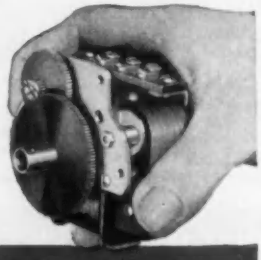
City _____ State _____

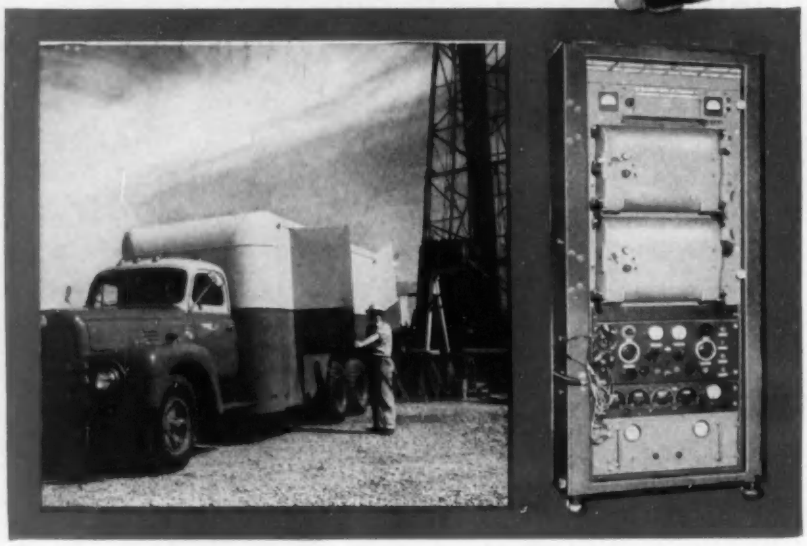
BARBER COLMAN

Barcol®

Small Motors

maintain tension of film logs on Halliburton surveying trucks





To show underground characteristics of oil wells, graphic records are produced on transparent film by field trucks of Halliburton Electrical Well Services, Duncan, Oklahoma.

Two Barcol type OYAZ reversible geared motors are located in each of the two film magazines of the log recorder and are connected in opposition to maintain tension on the film. These Barcol motors were chosen because of their ability to provide smooth torque at all speeds, whether driven in the same or the opposite direction from which they would normally rotate.

Two Barcol type GYAZ motors are also used in similar manner to maintain tension on a 16 mm. film strip which records well depth numbers on the logs. "Plus" features of Barcol motors used in this application include rugged, precision-built gear trains . . . porous bronze bearings . . . hardened and ground stainless steel shafts . . . high starting torque.

If you have a design problem involving small motors, let Barber-Colman engineers help you solve it with the exact motor for the job.

FREE DATA SERVICE ON WIDE LINE OF SMALL MOTORS

The Barcol line includes unidirectional, synchronous, and reversible motors —up to 1/20 h.p. With and without reduction gearing—open or enclosed types. Expert engineering service available. Write today, tell us your problem, ask for free data sheets.

BARBER-COLMAN COMPANY

DEPT. N, 1212 ROCK STREET, ROCKFORD, ILLINOIS

Small Motors • Automatic Controls • Industrial Instruments • Aircraft Controls • Air Distribution Products • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

wiper longer life. The gland, which consists of the wiper, bearing and self-compensating packing, can be replaced without dismantling the cylinder. The cylinder can be used with interchangeable mountings—foot, flange, pivot, clevis or trunion. National Pneumatic Co., Inc., 125 Amory St., Boston 19, Mass.

For more information—
Circle 85, inside back cover

Air and Hand-Operated Hydraulic Power Unit

This air pump and hydraulic jacking unit combination is operated either by pump or by hand. When under air operation the jacking unit provides an extremely rapid rise until it contacts the load, and then a safe steady rise with the load to the extent of its rise. At the top of the rise the air is automatically shut off. In case of an emergency where the air supply is interrupted, the unit can be operated by hand.

One model of the power unit has controlled lifting and lowering speed, instant control of stopping and starting and up to 6000 lb capacity on the head. The unit will operate on as little as 80 psi air pressure. Joyce-Cridland Co., 2027 E. First St., Dayton 3, Ohio.

For more information—
Circle 86, inside back cover

Solenoid-Operated, Spring Return Air Valve

A completely enclosed, ¼-in., four-way air valve has an aluminum cover. Model 541 is 6¼ x 3¾ x 2¾ in. wide. The cover is gasket-sealed with locked-in screws. Mechanical Air Controls, Inc., 10030 Capital, Oak Park, Detroit 37, Mich.

For more information—
Circle 87, inside back cover

Coaxial Metering Flow Valve

The functions of both a precision metering valve and a by-pass valve are combined in this unit, which is capable of quick and simple vernier ad-

justment to provide an accurate flow of liquid or gas, under constant pressure. It is designed for hydraulic and pneumatic systems with pressures up to 5,000 psi.

Applications include flow meters and pump and valve systems where by-pass flow must be regulated in laboratory equipment, fuel systems, fire control systems of weapons, steam throttling, aircraft, guided missiles, motored servo mechanisms, automation equipment. The new valve is available from ⅜ through 1½ in. NPT, and in manual and motor-driven types. It is readily adjusted and serviced from the top without removing from the system. Ard Mfg. Corp., 85 Tremont St., Meriden, Conn.

For more information—
Circle 88, inside back cover

Semi-Direct Lift Solenoid Valve

This solenoid valve is normally closed (when de-energized). It is packless and full-ported. Described as suitable for use with air, gas, freon, methyl chloride, water, oil, low pressure steam or other media not harmful to bronze or 316 or 416 stainless steel, the unit's coil lifts the pilot valve assembly from the pilot valve orifice, thus relieving the pressure on the top of the piston. Line pressure then lifts the piston. When there is no line pressure, the pilot valve assembly engages the piston directly lifting it from the full port area. This assures positive opening even at 0 psi. When the solenoid is de-energized, a spring over the piston provides positive closing.

The new valve is made to fit ¼, ¾ and 1-in. pipe sizes. Range is 150 psi pressure down to 0 psi. Useful temperature range is to 250 F.

The valve has an explosionproof housing for use in hazardous locations. Atkomatic Valve Co., Dept. 1, 545 Abbott St., Indianapolis, Ind.

For more information—
Circle 89, inside back cover

Spring Loaded, Guided Relief Valve

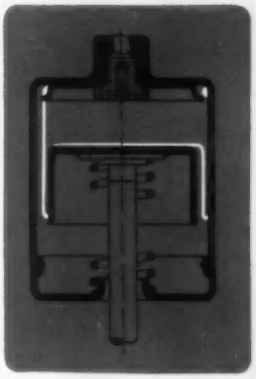
A relief valve for oil is used to control pressure in clamping or feed circuits and is especially recommended

NEW

flangeless bead-type

Bellofram*

PISTON SEAL



...easy to apply

NEW CLASS 1 BELLOFRAM

The new solid head Class 1 Bellofram is a long stroke, deep convolution piston seal diaphragm developed for all pressure sealing applications. With the "O" ring bead-seal characteristic, it will operate efficiently at pressures up to 500 p.s.i. — or up to ten times the rating of ordinary diaphragm seals.

EASE OF APPLICATION SIMPLIFIES YOUR DESIGN PROBLEMS

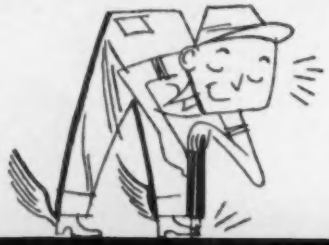
Actuators using Class 1 Belloframs have longer stroke — are smaller, lighter, much easier to design and manufacture — do not require costly machining or precision alignment. Bellofram's *rolling action* (not sliding) minimizes friction losses. Dynamically stable Belloframs are made of modern fabrics and elastomers for high resistance to fatigue and extreme cycle life. The bead is not subject to operational stress, due to provable wall-friction coefficients and narrow semi-circular convolution of diaphragm under pressure.

FLANGELESS BELLOFRAMS FOR *YOUR* APPLICATION

Put this major improvement in piston seal design to work for you now. Bellofram's unduplicated features include resistance to vibration and chemical action — operation over a wide temperature range — elimination of leakage — control of effective area to within 0.1% over complete working stroke. No lubrication needed — no maintenance except simple, infrequent replacement — accurate, economical operation where ordinary seals fail. Outline your application and submit a sketch to find out how a standard or custom-engineered Class 1 Bellofram can solve your pressure application problems. Your data considered confidential. Write today.

*Trade Mark

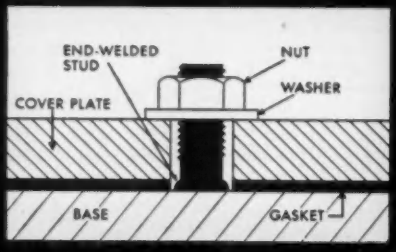
Bellofram
CORPORATION
141 MOODY ST., WALTHAM, MASS.



"STUD" NELSON
SECURES
COVER PLATES
IN A FLASH!

Pfft! A split second with a NELWELD® gun and you've got a sturdy end-welded stud right where you want it . . . ready to line up with the cover plate hole. That's real speed!

Multiply the saving in time by the number of fastening locations on your product. Add what you save by eliminating drilling and tapping; then figure the heavy bosses you won't need.



NELSON® studs . . . used to hang, handle or hold . . . come in many shapes, types and sizes.

Nelson Field Engineers, all cost-reduction specialists, operate from a nationwide chain of field offices and warehouses. They're trained to efficiently handle all your needs for studs, equipment, or fastener engineering. Write for details.

Stud Nelson

Fasten it Better at Less Cost with

NELWELD®

NELSON STUD WELDING
2750 Toledo Avenue
Lorain, Ohio

Please send more information on cost-saving stud welding applications.

NAME _____

COMPANY _____

ADDRESS _____

CITY AND STATE _____

NELSON STUD WELDING DIV. OF GREGORY INDUSTRIES, INC. LORAIN, OHIO

where pressure is controlled by a continuous flow through the relief valves. In operation, the pressure force on the piston is equal to the spring force against it. As the pressure increases, the spring is compressed and the piston uncovers the outlet ports. The fluid in the spring cavity dampens the valve and prevents chatter.

Both piston and its sleeve are of hardened steel, ground and honed. Because of the fast-opening characteristic, these valves are said to be able to relieve almost all pressure surges.

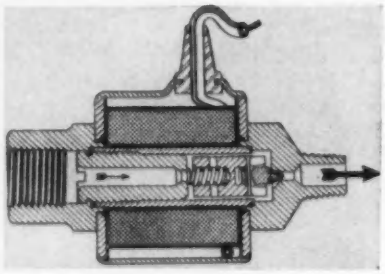
The series is available in a cartridge style for oil at 10 to 600 psi pressure range, with a hand knob pressure adjustment, and in $\frac{3}{8}$, $\frac{1}{2}$, and $\frac{3}{4}$-in. pipe sizes. Fluid Controls, Inc., 1284 N. Center St., Mentor, Ohio.

For more information—
Circle 90, inside back cover

Capillary Tube Fitting

This $\frac{1}{16}$-in. capillary fitting works on the same principle as other fittings by this same maker. There is no flaring required. No special tools are required for installation nor is any preparatory work on the tube required. To install, the capillary tubing is slipped into the fitting and the nut turned until a tight seal is secured. This new fitting is available in brass, aluminum, steel, stainless steel and Monel. Crawford Fitting Co., 884 E. 140 St., Cleveland 10, Ohio.

For more information—
Circle 91, inside back cover



Solenoid Valve Leakproof Up to 200 Psi

A straight-through flow solenoid valve, that operates in any position, may be mounted quickly and easily without brackets. This unit is $2\frac{5}{8}$ x $1\frac{3}{8}$ in. dia and weighs 5 oz.

No gaskets are used in this valve.

The important parts are stainless steel and all parts are silver-brazed for rigidity. Models are available in 6, 12, 24 v dc, and 110, 220 v, ac, completely waterproof and for use in ambient temperatures from −65 F to 350 F. Orifice sizes range from $\frac{1}{16}$ to $\frac{1}{8}$ in. dia, while the inlet connection is $\frac{1}{4}$ in. NPT and the outlet $\frac{1}{8}$ in. NPT. Lead lengths up to 24 in. are furnished without additional charge. This valve is capable of more than 1000 cycles per min. Specialty Products Co., Inc., 3725 Monitor Ave., Minneapolis 16, Minn.

For more information—
Circle 92, inside back cover

Pop-Off Relief Valve

This relief valve is said to seal tight with no leakage below release pressure and it will reseat dead tight. Sealing is provided by a resilient member fitted into the poppet head, which seats in a spherical section in the valve body. When in the closed position the metal-to-metal seating limits the compressive load on the resilient seal and contains it to withstand the pressure load. The spherical valve seat eliminates the need for close stem alignment and troublesome close sliding fits in the sealing area. Recommended for applications where pressures are from 1 to 125 psi and maximum flow and minimum pressure drop are required. James-Pond-Clark, 2181 E. Foothill Blvd., Pasadena 8, Calif.

For more information—
Circle 93, inside back cover

Water Pressure Release Adapter

During the operation of automatic washing machines and dishwashers, the hot water builds great pressure in the hose connecting the machine with the home faucet. When the hose is disconnected from the faucet, the hot water gushes forth in all directions, causing damage and, often, personal injuries. The pressure built up in the hose is channelled directly into the sink before the hose is disconnected by this adapter. The housewife accomplishes this merely by turning the small release valve on the side.

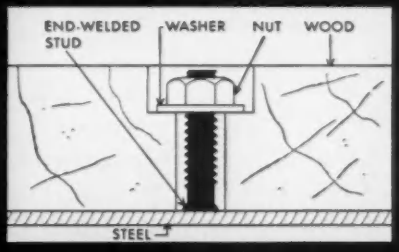
The No. 451 adapter is designed to

"STUD" NELSON FASTENS

WOOD to STEEL IN A FLASH!

Shipyards and railroads have long been users of the NELWELD system of securing wood decking—and builders fasten wood nailers the same way.

In like manner, designers of skids, pallets, dollies and other wood-and-steel products are also benefiting by the NELWELD® method. End-welded studs are a "natural" in designing outside surfaces free from bolt heads and projections—saves drilling and tapping the steel members, too.



The pay-off is—NELSON® studs are made in many other different sizes and shapes—allowing design flexibility you never believed possible.

The aim of every Nelson Engineer is to improve fastening and reduce cost. He will arrange a demonstration in your plant or furnish a trial rental unit. Write or phone for details.

Stud Nelson

Fasten it Better at Less Cost with

NELWELD®

NELSON STUD WELDING
2751 Toledo Avenue
Lorain, Ohio

Please send more information on stud welding wood to steel, and other cost-saving applications.

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COMPANY_____

ADDRESS_____

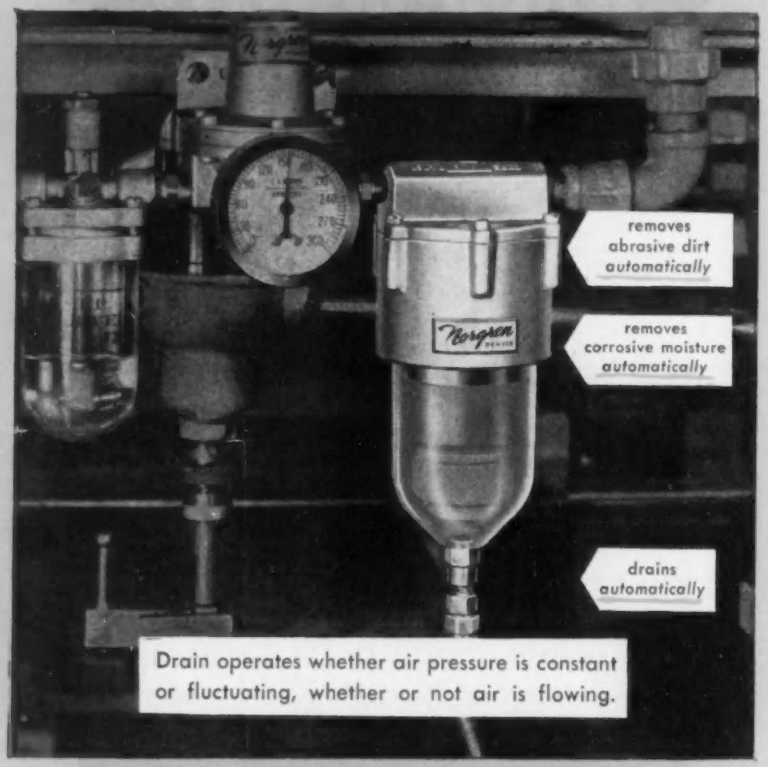
CITY AND STATE_____

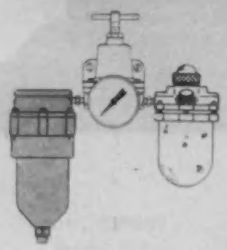
NELSON STUD WELDING DIV. OF GREGORY INDUSTRIES, INC. LORAIN, OHIO

Norgren

automatic-drain filter

new, modern filtering unit essential in oil-fog lubrication of bearings


removes abrasive dirt automatically
removes corrosive moisture automatically
drains automatically
Drain operates whether air pressure is constant or fluctuating, whether or not air is flowing.



NORGREN BEARING LUBRO-CONTROL UNIT includes automatic-drain filter, pressure regulator and Micro-Fog Lubricator. It filters grit, pipe scale and moisture from the air line, prevents contamination of oil supply; regulates the air-line working pressure; supplies accurately controlled, air-borne oil-fog lubrication for bearings...assures equal distribution of oil-fog through as many as 40 outlets, for multi-bearing lubrication.

WRITE FOR COMPLETE DATA

C. A. Norgren CO.
3428 So. Elati, Englewood, Colo.

Oil Fog Lubricators • Pressure Regulators • Air Filters • Valves
Hose Assemblies

fit those faucets equipped with aerators or having threads onto which aerators normally fit. P & G Supply Co., Inc., 1455 Boston Road, Bronx 60, N. Y.

For more information—
Circle 94, inside back cover

Hydraulic Hose and Couplings

This line of hydraulic hose and couplings is for medium-high and high pressure service. The couplings, manufactured to JIC standards, feature a "double-wedge" grip which, the manufacturer claims, makes possible assembly on rubber-covered hose without skiving. Through use of a special slotted bushing, the manufacturer has made retightening of the coupling possible on the hose without disassembly, when and if it comes loose through vibration or flexing. No special tools or mandrels are required for assembling these couplings on the hose. Joy Mfg. Co., Oliver Bldg., Pittsburgh, Pa.

For more information—
Circle 95, inside back cover

Compressed Air Filter With Permanent Core

This filter has a permanent core or "cartridge" of Teflon felt, which is both chemically inert and water repellent. Major advantage of this core is said to be its water repellency, which prevents accumulation of water—the major cause of clogging in other materials used. Air flow rates remain high since incoming moisture literally "rolls off" the fluorocarbon fibers to collect at the base of the receptacle, where removal is simple.

The filters are rated at 20 cfm, at a maximum operating pressure of 125 psi. Pipe size connections are $\frac{1}{4}$ in. ips. Porous Plastic Filter Co., 30 Sea Cliff Ave., Glen Cove, N. Y.

For more information—
Circle 96, inside back cover

Sump Drain for Compressed Air Systems

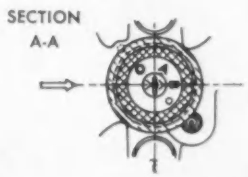
Intended for installation on receiver tanks, air line sumps, drain legs, pneumatic storage tanks, this drain meas-

NEW

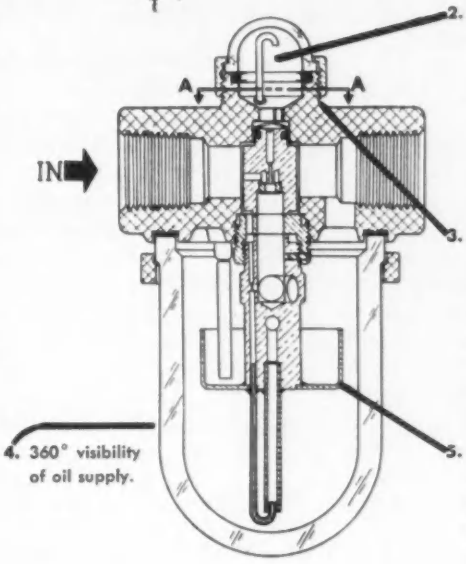
NORGREN MICRO-FOG LUBRICATORS FOR AIR TOOLS AND CYLINDERS

SIMPLIFY YOUR DESIGN PROBLEMS

distinctive Norgren features



1. VARIABLE VANE VENTURI View showing Index Marks "A" and "B" for Position of Rotatable Vane Type Venturi Plug.



2. 360° visibility of the oil feed

3. Oil feed controlled by auxiliary air circuit...gives an accurate and uniform rate of oil feed.

4. 360° visibility of oil supply.

5. Constant oil level...rate of oil feed not affected by oil supply.

6. Ability to produce a very fine oil fog and deliver it over long distances, through complex piping systems, and obtain equal distribution to multiple lubrication points.

variable vane feature provides greater flexibility

- ***meet a broader range of operating conditions***
- ***each can handle jobs now done by several sizes of lubricators***

A simple adjustment inside the dome provides a wide range of air flow for varying conditions or different applications. Thus each lubricator meets a broader range of operating conditions and can handle jobs now done by several sizes of lubricators.

For example, at 80 psi the ⅜" size can be set for a low flow range of 5 to 9 cfm, a high range of 50 to 100 cfm, or any intermediate range desired.

The new line includes 20 models. Flow capacities: ¼", 5 to 40 cfm; ⅜" & ½", 5 to 100 cfm; ¾" & 1", 5 to 250 cfm. Sizes: transparent bowl, ½ pt.; tank type, 1¾ gal. and 4½ gal.

FOR DETAILS WRITE FOR FORM 496 →

C. A. Norgren CO.
3428 So. Elati, Englewood, Colo.

COBRA C is the *new* chromate finish for high corrosion protection and bright finish on copper, brass or bronze. Can be used on solid or plated copper or brass; for cleaning and deoxidizing copper or brass parts; for removing flux on soldered parts.

Just *one* advantage of Luster-On COBRA C is that it can be diluted . . . cutting costs for you up to 25% over regular COBRA.

COBRA C eliminates hazardous nitrous oxide fumes that most bright brass treatments give.

COBRA C can be used at room temperatures or slightly elevated.

And, IN ADDITION, COBRA C

- Produces a permanent lustrous finish even in recessed areas.
- Stands over 100 hours standard salt spray; assures long life.
- Can be handled immediately after treatment cycle — no staining or finger marks.
- Replenishment possible with same concentrate.
- Exhaust of bath in use is optional — not required.
- Excellent paint bond qualities.

LUSTER-ON® — the first in the field and still the leader.

Write for full data sheets, and send a part for free processing.

L-14

THE *Chemical* CORPORATION

59 Waltham Ave., Springfield 9, Mass.

ures 5 in. dia by 8½ in. high. It will automatically collect and discharge all moisture, free oil and contaminants at any line pressure from 10 to 250 psi. Made of cast aluminum, the unit can automatically collect and discharge over 400 gph of water.

The 150SD-4 is threaded for ¼ in. pipe nipple on the inlet. A cellular plastic float is used to actuate an air valve. This in turn allows full line pressure to force out accumulated moisture, closing the discharge port and reseating the float without wasting air. This new sump drain is now available from distributor stocks maintained in various principal centers. Wilkerson Corp., 3387 S. Platte River Drive, Englewood, Colo.

For more information— Circle 97, inside back cover

Fluid System Strainers

These line strainers are designed to protect valves and pumps, for refrigeration applications as well as for water, oil, air and general usage. Fabricated of ferrous metals and non-ferrous metals for use with specified fluids, they are offered in cleanable and non-cleanable models.

These strainers are built with reinforced Monel and stainless steel screens of 60 and 80 mesh, with up to 180 sq. in. of screen area. Finer meshes are furnished on order. These strainers are available with connection sizes up to ⅜ in. SAB, 3⅜ in. sweat and 1¼ in. NPT with flange. Detroit Controls Corp., Detroit, Mich.

For more information— Circle 98, inside back cover

ENGINEERING MATERIALS

Impact and Abrasion Resistant Steel Alloy

This alloy steel's high initial hardness (470-520 Bhn), as shipped, is combined with high resistance to impact. This initial hardness is retained in sections up to 6 in. thick, with only a slight reduction in hardness of thicker sections.

Tensile strength is said to exceed 220,000 psi. Yield point exceeds 180,000 psi making this alloy resistant to flow and distortion. These values are retained at operating temperatures ranging from −50 F to 450° F. Charpy impact values are approximately 20 ft-lb.

The new steel can be welded by conventional arc-welding methods; its hardness is affected only in the immediate area of the weld. It is machinable, using heavy duty equipment, or it can be finished by grinding. It is magnetic, which means that should teeth or other parts disengage, they will be picked up by magnetic separating equipment before entering crushers. Differential hardness of castings is obtainable, when a need exists for soft center sections—such as are required for easy machining or splining of bores.

No difficulties have been encountered in casting; this alloy has been cast in the form of large crusher segments and down to the smaller-sized dipper teeth. Shrinkage rate is comparable to that of most cast steels and special patterns are not usually required. In many cases, patterns designed for use with austenitic magnanese steel can be used. American Steel Foundries, 410 N. Michigan Ave., Chicago 11, Ill.

For more information— Circle 99, inside back cover

Resists Rusting, Corrosion Of Hot Surfaces

Formulated of silicone and silver aluminum, this paint is said to resist up to 1600 F while repelling rust and corrosion under the severest weather conditions. One test, carried on over a period of 14 months on a pipe carrying air heated to 1600 F and exposed to heavy rains, showed this paint had resisted oxidation, corrosion and rust. C. H. Dragert Co., P. O. Box 5092, Dallas, Texas.

For more information— Circle 100, inside back cover

Lower-Priced Acrylic Sheet

A cast acrylic sheet ranges from 10 to 25 percent less in price, depending on thicknesses and sizes, than the

PERHAPS YOUR TIMER WILL BE THE 661st

How do you know we can supply you with the timer that will do your job best? Because we have 19 years of experience in developing new timers to meet our customers widely varied requirements. If one of our standard timers won't do it—or one of the 660 combinations we have thus far developed from our 17 basic units—our engineers will develop the 661st combination, for your specific needs.

We manufacture a complete line of timers in these 4 broad classifications:

TIME DELAY TIMERS • INTERVAL TIMERS
RE-CYCLING TIMERS • RUNNING TIME METERS

And since we maintain large stocks of our 17 basic units, we can assure you of rapid deliveries—and of good deliveries even on special orders. Automation? We're in it up to our ears...just put your problem up to one of our timer specialists. Your inquiries will receive prompt attention.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

131 OGDEN STREET, NEWARK 4, N. J.

Sticks to the job!

Time waits for no man, but Metal-Cals withstand time, weather and wear as they stick to the job of identifying your product! These anodized, etched aluminum nameplates are permanent and indestructible. Backed by a pressure-sensitive adhesive, they go on easily—to stay! Metal-Cals remain clear, sharp and easy-to-read. The letters, characters and colors are a permanent part of the anodized, .003-inch aluminum foil. They slash application costs, too, because they are faster to apply and require no rivets, screws, pins or other fastening devices. So, to identify... specify... METAL-CAL!

Montgomery Ward has specified Metal-Cals for marking their ¼-inch electric power drills. They have standardized on Metal-Cals for permanent, distinctive product labeling.

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Use this coupon for FREE SAMPLES AND AN EXPLANATORY BROCHURE that show how Metal-Cal, the anodized, etched aluminum nameplate, sticks to the job of trademarking or providing clear, sharp diagramming or serial numbering for your products.

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Inglewood, California
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B-8

same manufacturer's present standard sheet—which it will also continue to supply.

According to the manufacturer, this material is a general purpose sheet with the same physical and chemical properties as their standard sheet, including outdoor weatherability. It is supplied as unmasked, untrimmed material, clear, transparent and colored, packaged in standard groupings of sizes and thicknesses. Rohm & Haas Co., Philadelphia, Pa.

For more information—
Circle 101, inside back cover

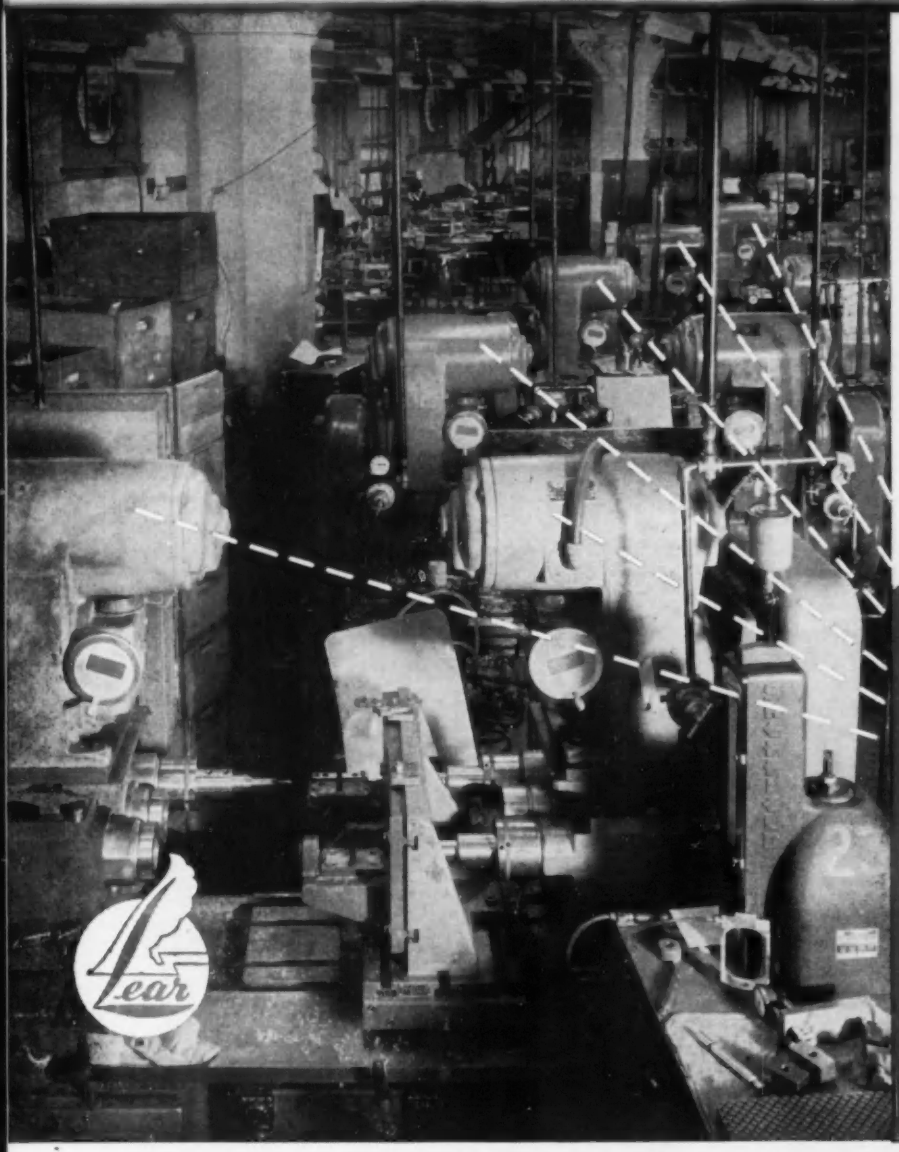
Silicone Rubber-Coated Glass Fabric

A thin lightweight silicone rubber-coated fabric is recommended by its maker for use as electrical insulation, gasketing, very sensitive diaphragms or for aircraft septum material. It weighs only 4.5 oz per sq yd, and is the thinnest silicone rubber-coated glass fabric known. The base glass fabric is a new 0.001-in. cloth coated to minimum thicknesses. However, this same cloth has been silicone-rubber coated to 0.007 in. and 0.010-in. thicknesses for increased air impermeability. It has a dielectric strength of 1100 to 1400 v per mil, a useful temperature range from —70 F to 500 F, and is exceptionally flexible and rubbery. Connecticut Hard Rubber Co., 407 East St., New Haven, Conn.

For more information—
Circle 102, inside back cover

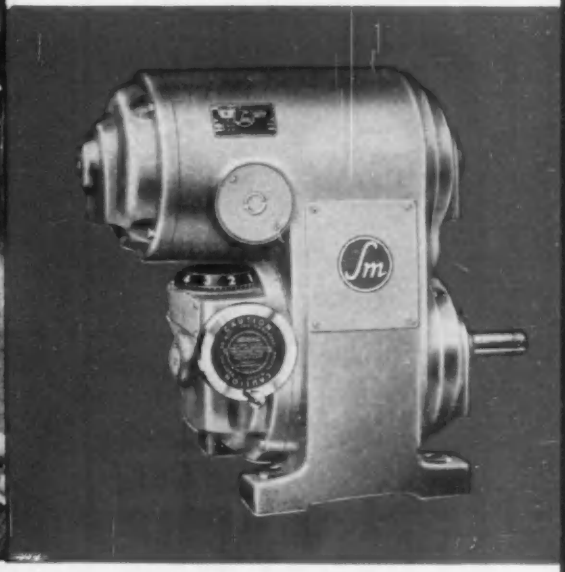
Bearing Material Runs With or Without Oil

This bearing material is asserted to operate at temperatures of —120 F to 500 F. The manufacturer states that exceptional wear characteristics are provided at extreme temperatures. The material is comprised of 52 percent bronze-tin and 48 percent molybdenum disulfide, graphite and a thermosetting resin. These ingredients are combined in a semi-solid substance having oil absorptive qualities as well as its inherent dry-lubricating characteristics. Ultimate compression strength is 22,700 psi. The metal structure is developed from powdered metal processed for uniformity fused



LEAR, INC., ELIMINATED FINISH GRINDING OPERATION WITH SPEED-TROL

Speed-Trols on boring machines at Lear, Inc., Grand Rapids, Mich., resulted in elimination of a grinding operation and a reduction in manufacturing costs. This was accomplished through Speed-Trol's infinite speed adjustment and accurate speed regulation which allowed selection of the best cutting speeds for Carboloy or diamond tipped boring tools and boring to extremely close tolerances which obviated the need for a former final grinding operation.



Industry Names Speed-Trol Production Advantages

In a nation-wide user survey of Sterling Speed-Trol Variable Speed Electric Power Drives:

86% Increased Production. **48%** Improved Product Quality. **64%** Reduced Production Costs. **42%** Modernized Equipment and Machines. **20%** Reduced Spoilage and Rejects. **28%** Increased Machine Versatility. **18%** Increased Plant Safety. **34%** Improved Employee Morale. **62%** Lowered Maintenance Costs. **46%** Saved Space. **18%** Simplified Operations. **16%** Synchronized Operations.

Investigate the possibilities of bringing some of these Speed-Trol production advantages to your plant. Sterling Engineering Sales Offices and over 400 Distributors and Service Shops throughout the nation effectively serve every industrial, commercial and agricultural area.

20-PAGE ILLUSTRATED CATALOG ... Sterling Speed-Trol, Slo-Speed, Klosd and Klosd-Tite Electric Power Drives. Write for catalog No. 203.

There is a Sterling Electric Power Drive to Meet Virtually Every Requirement

Sterling Slo-Speed Electric Power Drives—for geared low speed at its best
Sterling Klosd and Klosd-Tite Motors—for constant normal speed at its best

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Plants: New York City 51 • Chicago 35 • Los Angeles 22 • Hamilton, Canada • Santiago, Chile

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Special Motor Designs

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☐ SQUIRREL CAGE
☐ BRAKEMOTORS
☐ WOUND ROTOR
☐ D-C MOTORS
Generators, M-G Sets

*My name is*_____

*They call me a*_____ *(title)*

*At*_____ *(company)*

_____ *(street address)*

_____ *(city) (zone) (state)*

STAR-KIMBLE
MOTOR DIVISION
Miehle Printing Press and Mfg. Co.
211 Bloomfield Ave., Bloomfield, N. J.

by effect of heat on the resin. It can be machined to close tolerances. Booker-Cooper, Inc., 6940 Farmdale Ave., N. Hollywood, Calif.

For more information—Circle 103, inside back cover

Plastic with High Flexural and Impact Strength

This material is a two-step, cord-filled phenolic molding material with a minimum flexural strength of 18,000 psi, and a minimum Izod impact strength of 14 ft-lb per inch of notch, according to the manufacturer's mechanical tests. Other properties of FM 11679 Black include a plasticity that is medium to hard, a heat resistance in molded parts up to 250 F and a compressive strength of 18,000 psi. Fiberite Corp., Winona, Minn.

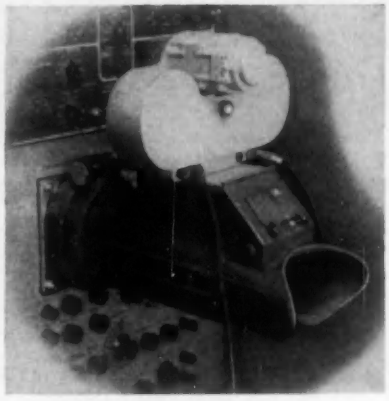
For more information—Circle 104, inside back cover

Miniature Molded Rubber Parts

Custom molded rubber parts having complex structure can be produced in miniature with dimensional tolerances as close as ±0.001 in. by means of injection molding, according to the manufacturer. The "flash" found in parts molded by other means is eliminated, together with such secondary operations as hand or machine trimming. The manufacturer claims that many compounds of Neoprene, Buna N and silicone synthetic rubbers can be molded. Among the applications expected for this new type of molded parts are relief values, spraying value seal, transformer terminal insulator, various hydraulic seals. Dep't KP, Minnesota Rubber & Gasket Co., 3630 Wooddale Ave., Minneapolis 16, Minn.

For more information—Circle 105, inside back cover

ENGINEERING EQUIPMENT



Oscilloscope Camera

A 35 mm camera for continuous recording of oscilloscope traces, The Model OC-1 weighs 6 lb, with a film capacity of 100 ft. The camera may be mounted directly on the bezel of any 5-in. oscilloscope. Simultaneous binocular viewing and recording, illuminated identification card and a flashing lamp time reference are provided.

The film transport rate may be set between 1 and 300 in per sec by means of a continuously variable remote motor control. Lower speeds can be achieved by gear substitution and higher speeds up to 400 in per sec can be reached with special starting acceleration control. Less than 15 sec are required for removing exposed film and reloading with daylight loading spools. The film consumed in starting or stopping at maximum speed is less than 2 ft.

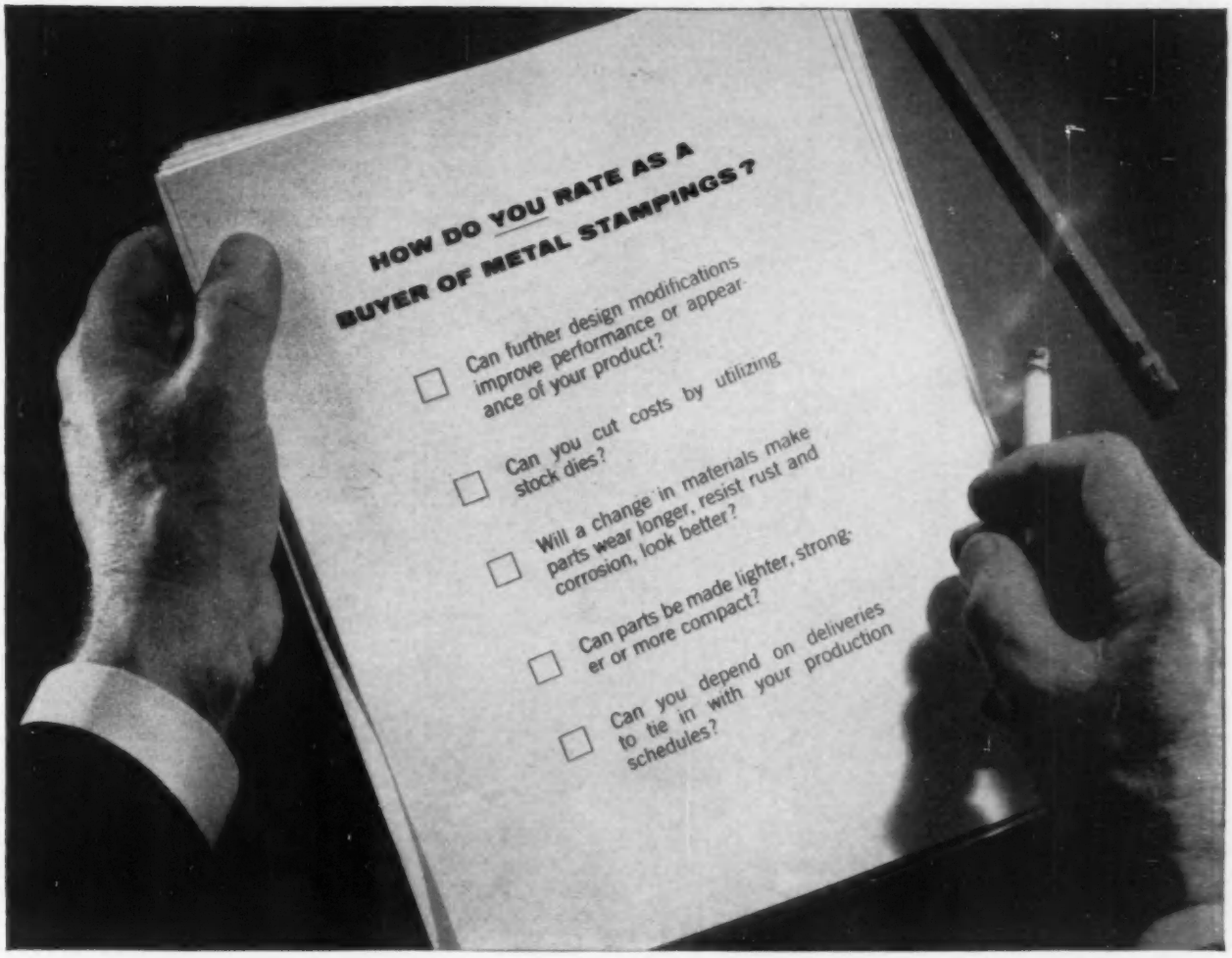
A choice of f/1.5 or f/2.8, 50-mm coated lens with iris diaphragm is offered, giving an image reduction ratio of 4:5 in the usual 5 in. oscilloscope installation. Available as an accessory is a variable delay timer which permits an event to be initiated from 0.5 to 5 sec after camera starts. Brea Instruments, P. O. Box 248, Brea, Calif.

For more information—Circle 106, inside back cover

Template Paper Rolls Up To 62 In. Wide

Industrial photographic papers for making copies of templates are now available in widths of 48, 54 and 62 in. Roll width previously has been limited to 42 in. The new widths are available in both 85 and 105 g weights.

The wider rolls are designed pri-


HOW DO YOU RATE AS A BUYER OF METAL STAMPINGS?
Can further design modifications improve performance or appearance of your product?
Can you cut costs by utilizing stock dies?
Will a change in materials make parts wear longer, resist rust and corrosion, look better?
Can parts be made lighter, stronger or more compact?
Can you depend on deliveries to tie in with your production schedules?

can your metal stamped parts be improved or produced at greater profit* to you?

To tell you "how" and "why" it may be possible, The Crosby Company has just published an informative report: "Removing the Questionmarks from Metal Parts Procurement". In it, you will find specific ways in which Crosby can assist you in checking every major design and cost factor relating to metal stamped parts.

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marily for use in template work by engineering firms and automotive and aviation manufacturers, where widths greater than 42 in. are usually achieved only by splicing. Anken Chemical & Film Corp., Newton, N. J.

For more information—
Circle 107, inside back cover

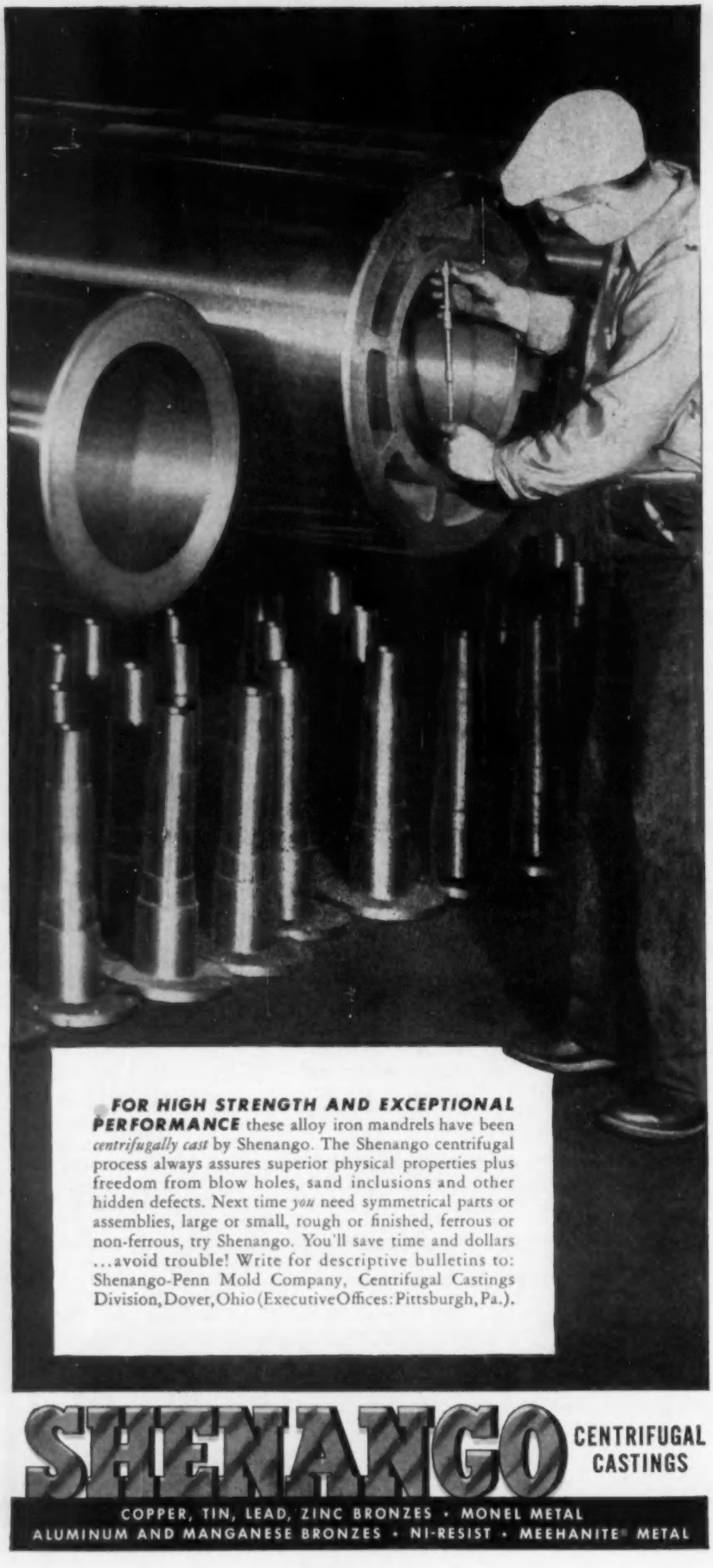
Contrast and Sharpness Increased In Reflex Prints

A new diffusing material to increase contrast and sharpness in reflex prints has been developed. It will increase the quality of any reflex print made on thin base stock (55 g, extra thin), according to the manufacturer, and is particularly effective in making the intermediate positive for whiteprint copying work. This diffuse sheeting is now being produced in cut sheets 10 x 13 in., 13 x 19 in. and 9 x 25 in., and in rolls 42 in. wide and in varying lengths. The cut sheets are packaged in half dozens in the smaller sizes and in three's in the 19 x 25 in. sheets. The new diffuser was developed for use in reflex printing on the translucent or transparent types of direct positive paper. The sheeting is an acetate base with a yellow diffusing pigment coating. Anken Chemical & Film Corp., Newton, N. J.

For more information—
Circle 108, inside back cover

Isometric Protractor

This protractor contains two sets of 180 deg graduations, each numbered from zero to 90 deg clockwise and counterclockwise from the main axes. Either half may be used for any one of the three isometric planes. A geometrical figure around the center of the protractor facilitates orientation of the instrument within the particular plane. The protractor has an outline of triangular shape in such relation to the graduations that by placing one of its edges against the T-Square, straight-edge or drafting machine blade, the correct orientation is automatically obtained. Two sets of numerals are provided, so that the figures can be read directly, no matter which side of the transparent protractor is placed on the drawing. With this instrument, any angle in any plane of the isometric drawing can be plotted


FOR HIGH STRENGTH AND EXCEPTIONAL PERFORMANCE these alloy iron mandrels have been centrifugally cast by Shenango. The Shenango centrifugal process always assures superior physical properties plus freedom from blow holes, sand inclusions and other hidden defects. Next time you need symmetrical parts or assemblies, large or small, rough or finished, ferrous or non-ferrous, try Shenango. You'll save time and dollars ...avoid trouble! Write for descriptive bulletins to: Shenango-Penn Mold Company, Centrifugal Castings Division, Dover, Ohio (Executive Offices: Pittsburgh, Pa.).
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COPPER, TIN, LEAD, ZINC BRONZES • MONEL METAL
ALUMINUM AND MANGANESE BRONZES • NI-RESIST • MEEHANITE® METAL

EEMCo

technical bulletin

a New MOTOR

for hydraulic pump in a guided missile

EEMCO Model D-638 was designed and produced for a leading airframe manufacturer for use in guided missiles where greatest power output per pound of weight is imperative. Specifications called for a 400 cycle A.C. motor operating on 200 volts, 20 amperes, at 2250 r.p.m. and a continuous duty cycle of 3.0 seconds at 6.5 HP and 15.0 seconds at 1.5 HP. **EEMCO's D-638,** weighing 17.5 lbs., was the answer. It also has a continuous rating at 5 HP of 2300 r.p.m., at 15.8 amperes. Complies with U. S. A. F. specification #32590 for 400 cycle A.C. motors. We invite your inquiry on adaptation of Model D-638 for other uses.

SPECIFICATIONS ★ TYPE D-638

Weight: 17.5 pounds ★ **Maximum Capacity:** 6.5 HP

Volts: 200 A.C. ★ **Amperes:** 20 at 6.5 HP ★ **Cycles:** 400

Duty cycle: 3.0 seconds at 6.5 HP
15.0 seconds at 1.5 HP

Continuous rating: 5 HP at 2300 r.p.m., 15.8 amperes, 200 volts.

Designers and producers of motors, linear and rotary actuators.

Electrical Engineering and Manufacturing Corp.

4612 West Jefferson Boulevard
Los Angeles 16, California

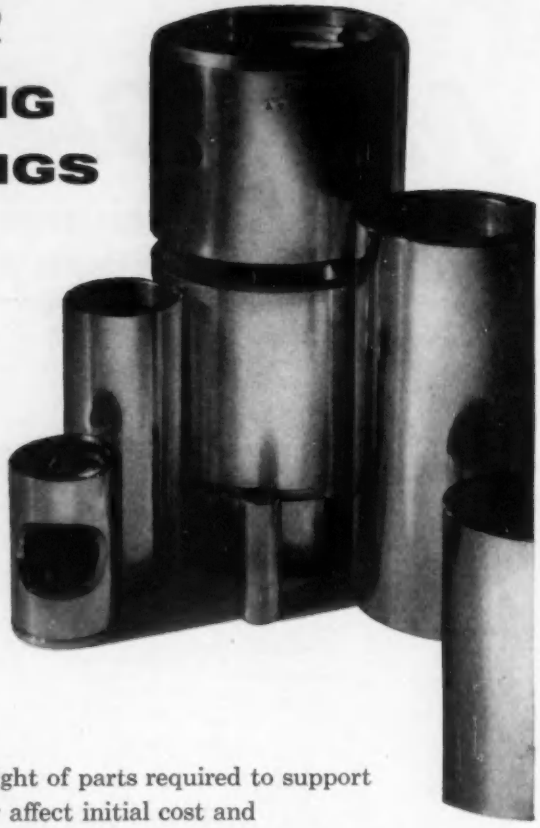
SIMPLE,

low cost housings suffice

FOR

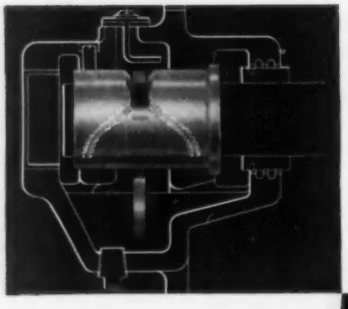
BUNTING

BEARINGS



The size and weight of parts required to support a bearing sharply affect initial cost and production costs. Because the Bunting Bronze Bearing is much smaller in diameter than other types of bearings required for similar applications, the supporting parts are lighter and lower in cost.

You can easily learn what economies can result from your use of Bunting Bronze Bearings. There is a Bunting engineer near you for consultation. Or write our Product Engineering Department at Toledo.



The weight of parts required to support a bearing varies directly as the square of the outside diameter of the bearing. The Bunting Bronze Bearing is much smaller in outside diameter than other types.

Bunting®

THE BUNTING BRASS & BRONZE COMPANY, TOLEDO 1, OHIO

BRANCHES IN PRINCIPAL CITIES • DISTRIBUTORS EVERYWHERE

or measured directly so that lines not parallel with one of the axes may be drawn without resorting to "boxing" or to the use of coordinates. John R. Cassell Co., Inc., 110 W. 42 St., New York 36, N. Y.

For more information—
Circle 109, inside back cover

Blueprint and Specification Reading Stand

An all-metal, 6-ft blueprint reading stand can be used as a free-standing unit or wall-hung, by means of a detachable easel. The 24 x 40½ in. easel swings 360 deg, tilts 25 deg. Blueprints are secured by six magnetized blocks. Entire assembly can be taken down and compactly stored on a hook. Young Radiator Co., Racine, Wis.

For more information—
Circle 110, inside back cover

D-c Power Supply

This ac to dc regulated selenium rectifier provides closely regulated d-c power in a compact unit. Regulation is ±1 percent from no load to full load with line voltage variation of 100 to 125 v. Response time is 0.2 sec under extreme load conditions. Output rating is 4 to 30 and 5 to 30 amp, full load. A-c input is single-phase, 60 cycle. Incorporates standard a-c input switch, fuse, pilot light, input and output posts. Leach Corp., 4441 Santa Fe Ave., Los Angeles 54, Calif.

For more information—
Circle 111, inside back cover

Internal Micrometer Measures ¼ to 8 in. Dia Bores

The irregular spacing of the gaging pins (anvils) in this micrometer is said to detect most forms of out-of-roundness. The pins are lapped to fit tightly and there is no open key-way in the head which would permit dirt to enter.

The instrument requires practically no individual skill or "feel," as the thimble which actuates the taper needle is controlled by a spring which insures repetition of measurement.

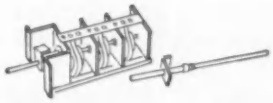
TAYLOR Laminated Plastics Vulcanized Fibre Shop Talk

TAYLOR FIBRE CO.

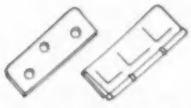
Plants in Norristown, Pa. and La Verne, Calif.

Tips for designers

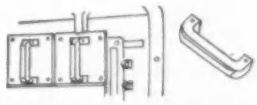
High temperatures in an aircraft generator posed a tough problem for rotor insulation . . . solved by Taylor Silicone Laminate.



Television tuner uses a shaft made of Taylor polyester glass rod . . . a strong material with excellent insulating qualities.



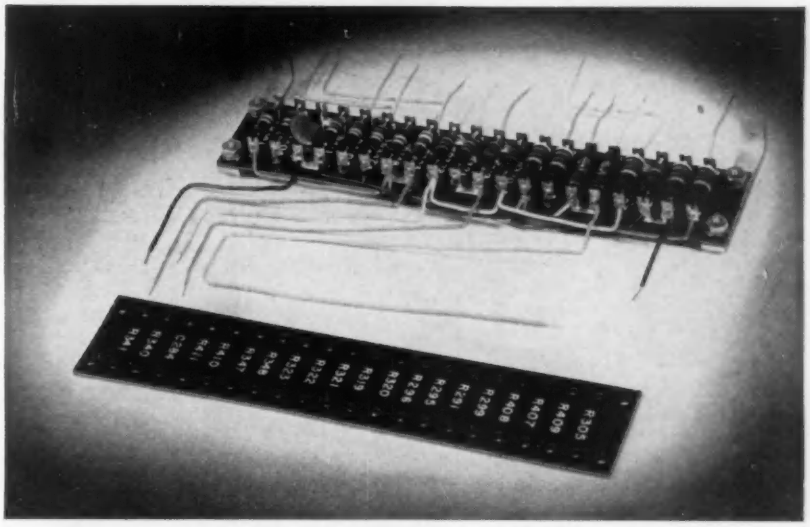
Refrigerator doors are hung with hinge spacers of Taylor Super White Vulcanized Fibre . . . tough, smooth, abrasion-resistant and readily formed.



Handles for heavy-duty fuse boxes are made of Taylor melamine laminate for resistance to arcs, corrosion . . . and for high mechanical strength.

TAYLOR FABRICATING FACILITIES

Your production problems can often be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and overall costs reduced by having Taylor fabricate finished parts of vulcanized fibre and laminates to your specifications. Efficient, modern facilities are ready to serve you. Write to Taylor about your specific requirements.



Terminal boards for Hewlett-Packard high-precision electronic instrument circuit are made of Taylor XXXP-301 laminate . . . chosen for its excellent, stable insulating qualities.

Unique hot punch laminates— *set new performance standards*

Taylor's new "300" series of paper base laminates were developed specifically to meet the stringent demands of modern electronic products. These hot-punch materials now make it possible for you to get premium physical and electrical properties . . . without premium price.

These new Taylor materials are unique. They're uniform all the way through . . . no surface overlay of resin. Their superior performance will add to the value of your products. And their excellent fabricating qualities will give you substantial savings in production. Equally important, you are always sure of these properties in every shipment, thanks to Taylor's methods of manufacture and strict laboratory control in each phase of processing.

A wide selection of grades of the new laminates have been developed to fill varied requirements of electronics manufacturers:

XXXP-301—the ultimate in electrical properties. Unusually high insulation resistance under all climatic conditions . . . low water absorption . . . excellent punching and staking . . . phenomenal recovery. Premium performance at standard price.

XXP-351—a high-grade laminate second only to XXXP-301, with closely comparable characteristics at a lower price.

Grade 353—a quality laminate with outstanding electrical and physical properties . . . priced for economy.

Grade 354—a laminate that's especially easy to fabricate. Good stability, low water absorption, and economical price.

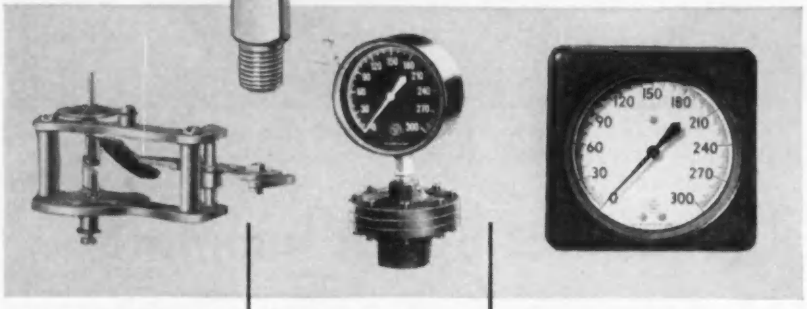
Grade 381—flame retardant with high arc resistance.

Plan to take advantage of these new laminates in the products you are now designing. Write to Taylor for full data, and for a consultation by a Taylor engineer.

an ACCO product

Helicoid Gages

gages for pressure, vacuum or compound service



Only Helicoid has the Helicoid movement.

Dials may be black, white or radiant.

Wall or stem mounting cases—flush, panel or flangeless cases.

Get the SUSTAINED ACCURACY only Helicoid can give

Everybody knows that the famous HELICOID movement outlasts a standard gear tooth movement. But did you know that Helicoid gage life is also tremendously increased by superior materials, methods and workmanship? Even the Bourdon tube in Helicoid gages is designed for maximum torque at minimum stress.

That is why Helicoid gages have exceeded 75,000,000 cycles at 1200 pulsations per minute. There is a Helicoid long-life gage to meet your every type of pressure indicating requirement. Ranges are to 20,000 p.s.i. and vacuum or compound.

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The 10:1 needle taper causes the micrometer thread to operate with ten times its normal accuracy; the instrument is therefore un-impaired by wear.

The measuring heads of the micrometer are fully interchangeable within the various sets, giving flexibility without sacrifice of accuracy.

The graduation on the thimble reads directly to 0.00005 in. in the small sets, and 0.0001 or 0.0002 in. in the larger sets. Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.

For more information—
Circle 112, inside back cover

Magnetic Amplifier Regulated Power Supply

This unit is rated at 22 to 32 v, d-c output at 300 amp, dc, and is designed to operate from 230 to 460 v, three phase, 60 cycle, a-c input with a ±10 percent tolerance on the a-c input voltage. The unit has a ±1 percent regulation and a 1 percent ripple, is enclosed in a 30 x 25½ x 72 in. cabinet and weighs 500 lb. This power supply contains no tubes and uses selenium rectifiers for the conversion elements and saturable reactors for the magnetic amplifier regulation circuitry. Perkins Engineering Corp., 345 Kansas St., El Segundo, Calif.

For more information—
Circle 113, inside back cover

Synchronous Motor Drive for Dials

Installation of these gear drives is simple: the knob drive is removed and the unit is attached with two screws. The drive is powered by a small synchronous motor. Two models are available, with output speeds at the driving pinion of 4 rpm and 30 rpm, respectively. A power switch is provided, as well as a manual disengage lever which lifts the pinion off the dial ring gear. The motor characteristics are such that the drive reverses itself whenever a stop is encountered. This feature makes it possible to use the Type 908-P dial drives as sweep drives and to produce warble tones. Stops are provided to attach to the dials to limit the sweep as desired.

Because the drives are synchronous, they are readily used with recording

So light a 3 year old can lift it!

. . . Imagine what this Power Products Lightweight can do for your equipment

Do a little "imagineering" in terms of your products! Wouldn't such dramatic weight savings create tremendous advantages in your equipment — make it easier to carry — eliminate heavy and costly frame structure, wheels etc.

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Answer DESIGNERS S. O. S.

For Dependable Protection on All Hydraulic and Low Pressure Systems

Simple, Balanced Design . . . is the answer to the growing preference for MARVEL Synclinal FILTERS. Designers are specifying Marvel Synclinal Filters to assure minimum maintenance and maximum protection. Results show Marvel Synclinal Filters superiority in maintaining the greatest degree of cleanliness of liquids in all hydraulic and low pressure systems with minimum downtime. Furthermore, when filter servicing is necessary, Marvels can be easily disassembled, cleaned and reassembled by any workman in a matter of minutes. Line types operate in any position and may be serviced without disturbing pipe connections.

Again and again, Marvel Synclinal Filters have demonstrated they meet all requirements of the most exacting users, that today—OVER 500 ORIGINAL EQUIPMENT MANUFACTURERS install Marvel Synclinal Filters as standard equipment!

A SIZE FOR EVERY NEED

Available for sump or line installation in capacities from 5 to 100 G.P.M. Greater capacities may be attained by multiple installation (as described in catalog). Choice of monel mesh sizes range from coarse 30 to fine 200.

IMMEDIATE DELIVERY!

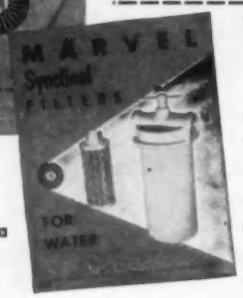
As in the past, Marvel continues to offer IMMEDIATE DELIVERY.

FILTERS FOR NON-FLAMMABLE HYDRAULIC FLUIDS

Marvel's most recent development is a filter for the efficient filtration of all types of non-flammable hydraulic fluids.

WATER FILTERS

Both sump and line type filters have been adapted for use in all water filtering applications. No changes have been made in the basic, balanced synclinal design.



Catalogs containing complete data available on request

MARVEL ENGINEERING COMPANY

625 W. Jackson Blvd. Chicago 6, Ill.

Phones — Franklin 2-3530 and Franklin 2-4431

COUPON

Without obligation, please send me complete data on Marvel Synclinal Filters, as follows:—

- ☐ Catalog #106—For Hydraulic Oils, Coolants and Lubricants
- ☐ Catalog #300—For WATER
- ☐ Data on filters for Non-flammable hydraulic fluids

Name .....

Title .....

Company .....

Address .....

City .....

State .....

PE-2

systems. The Type 908-P1 dial drive drives the Type 1304-B beat-frequency generator at the rate of 1 octave in 15 sec, a widely accepted standard for recorder chart drives. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

For more information—
Circle 114, inside back cover

Portable Insulation Test Set

Model 405A is rated 0 to 5000 v, ac. A continuously variable output voltage, current limiting high reactance transformer, a neon "breakdown" lamp to indicate arcing or corona in test circuit, a neon "leakage" lamp to indicate excessive current flow, grounds and short circuits, and an accurate (±3 percent) kilo-voltmeter connected directly across the output are provided. Input requirement is 115 v, ac, 60 cycle.

This unit was primarily designed for accurate, non-destructive testing of appliances and small electrical components by unskilled operators. Instrument measures 6 x 9 x 8½ in. Net weight is 15 lb. Associated Research, Inc., 3765 W. Belmont Ave., Chicago 18, Ill.

For more information—
Circle 115, inside back cover

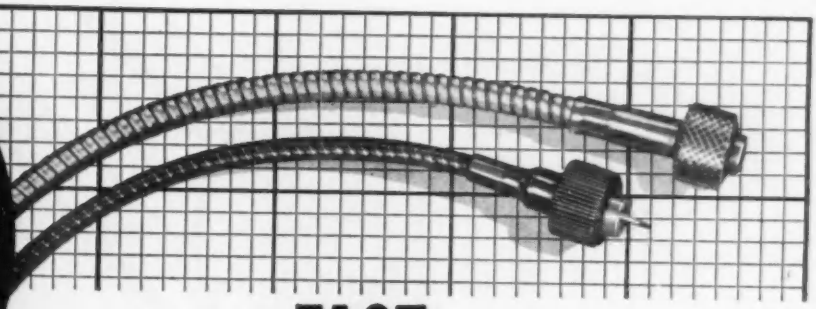
Accelerometer of the Potentiometer Type

This accelerometer is a potentiometer-type instrument, available in ranges between ±1 G and ±3 G, inclusive. To maintain constant operating characteristics over a wide temperature range, an internal, thermostatically-controlled heater has been designed into the instrument. This is said to permit operation (within specification limits) between −50 F and 160 F without a damping variation in excess of 0.1 critical. The instrument may be stored at temperatures between −65 F and 180 F without damage or change in characteristics.

The mass of the device is supported by a parallelogram-type leaf spring, giving it a virtually friction-free, straight-line motion along the sensitive axis. Mass travel in all directions other than along the sensitive axis is substantially restrained. Limit stops

FLEXIBLE SHAFT

Fact and Fiction



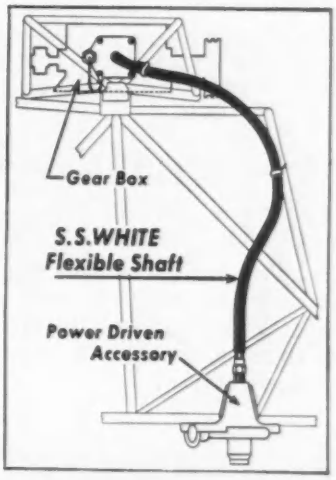
FACT

For transmitting power around turns, S.S.White Flexible Shafts simplify many design problems.

WHY? Because S.S.White flexible shafts are especially designed for use where rigid couplings are impractical. They do not require alignment, can be readily run around obstructions and are quickly and easily installed. Likewise, their adaptability to any design requirement gives you greater freedom in locating coupled parts to best advantage.

EXAMPLE — Power drive for an auxiliary pump

The specifications for this application called for mounting an auxiliary pump on the bottom of a helicopter fuselage. The closest power take-off to drive the pump was an accessory gear box located some distance away. An S.S.White flexible shaft, run around and over the intervening struts and frames made it possible to drive the pump *with a minimum of parts and with big savings in installation and assembly time.*



FLEXIBLE SHAFT FACTS FOR DESIGNERS

BULLETIN 5306 gives basic information and data about flexible shafts and tells how to select and apply them. Write for a free copy. Address Dept. D.

F-2

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
10 East 40th Street
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

FICTION Flexible Shafts are the same as steel springs

It's fiction because S.S.White flexible shafts are entirely different and in no way interchangeable with springs. S.S.White flexible shafts are specifically engineered for two basic functions – transmitting rotary power and remote control.

What's more – in design, in construction and in physical characteristics, as well as in performance – S.S.White power drive and remote control flexible shafts provide a range of qualities which are impossible to obtain in steel springs.

Shims stamped from LAMINUM® look like solid metal but actually are made up of layers of .002 or .003 inch brass or steel. The laminations are solidly bonded together, over their entire surfaces.

when a shim is

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here are the advantages you get:

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You machine only to easy tolerances. The laminated shim is *adjustable*—you simply peel laminations of .002 inch brass or steel with a penknife—to get exactly the spacing you need. You cut costs without sacrificing quality.

SIMPLIFIED USE:

Shims come to you in one "pack" for each application. They are precision-stamped to your exact specifications. No counting, no stacking, no miking. Gauge is always known. No dirt or grit can lodge between layers.

SPEEDED PRODUCTION:

Final fitting can be done right at the job. You don't have to take parts back and forth for further machining, grinding or filing. No special skill required. The laminations adjust spacing quickly, easily.

ADDED SERVICE FEATURE:

Throughout the life of the machines you produce, the simple removal of a shim lamination provides a unique adjustment for the take-up of wear. Original clearances can always be restored.

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on four sides of the mass, including the sensitive axis, prevent overtravel, enabling the instrument to withstand 40-G shocks without damage. The sensitive axis is aligned within ±0.25 deg of the mounting hole arrangement in both non-sensitive axes.

The double-contact brush of the potentiometer is attached to the mass and travels along the resistance winding as the mass is displaced. The brush is made of precious metal and designed to maintain a low noise level. The standard potentiometer winding is made with platinum alloy wire. Output is linear within 1 percent of full scale from the best straight line through the calibration points. The standard potentiometer in this accelerometer has a resistance of 14,000 ohms (±5 percent), with a center tap at the zero G point. Other resistances, with some change in resolution, or additional taps can be supplied at additional cost. If the instrument is to be operated from a regulated high-voltage power supply, precision-series, voltage-dropping resistors can be incorporated in the instrument. Maximum hysteresis will be less than 0.07 G. Operation in a vibrational environment relieves brush friction, which is a primary component of hysteresis in this unit.

The new accelerometer will withstand steady-state accelerations of 30 G on the non-sensitive axis, and 10 G on the sensitive axis. Shock accelerations of 40 G (5 millisecond duration) on the non-sensitive axis and 10 G (5 millisecond duration) on the sensitive axis will not damage the instrument. Operational life is in excess of 1 million cycles.

Damping is accomplished by silicone oil, and is normally 0.65 of critical at 75 F. However, the damping constant can be pre-set to any point between 0.5 and 1.0 critical.

The GOH is contained in a deep-drawn brass case with a solder-attached cover, hermetically sealing the basic instrument. The basic instrument can be operated at any altitude; however, thermostat operation is limited to 60,000 ft altitude and 95 percent relative humidity at 160 F. A Cannon-type receptacle is supplied for electrical connections. Weight of the instrument is 38 oz. Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.

For more information—
Circle 116, inside back cover

LOOK

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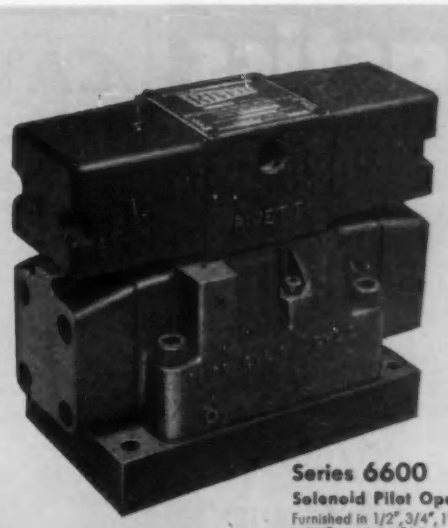

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9. May be mounted in any position.
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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

Stainless and High Alloy Tubing—Booklet, 48 pp, describes what is said to be the widest range of sizes ($\frac{1}{8}$ to 40 in. OD) produced in the tubing industry. It illustrates and describes the company's tubing manufacturing methods from metallurgical testing at the start, through welding, cold-working, annealing, pickling and passivating, testing and final inspection.

The booklet includes a practical guide to help users select tubing. It lists the nine basic classifications of this manufacturer's tubing and gives typical applications, characteristics and related information. A corrosion table is included to give further help in selecting tubing.

Other tables in the booklet show physical, chemical and electrical properties of other alloys (Inconel, illium R, Hastelloy alloys, titanium), theorectical weights of stainless steel tubing, wire and sheet metal gages and internal bursting and test pressures. Pertinent information on welding, bending, and installation techniques is also provided. Crucible Steel Co. of America, Henry W. Oliver Bldg., Pittsburgh 22, Pa.

Circle 117, inside back cover

Forgings—Brochure, 20 pp, has sections devoted to nomenclature, design layout, die design, tolerance tables, to help engineer design a rough forging that can be reproduced most economically while maintaining proper grain flow characteristics and providing maximum strength of material at desired points. Should also prove helpful where there is a choice as to how the part might be produced. Consolidated Industries, Inc., 10 Mixville Road, West Cheshire, Conn.

Circle 118, inside back cover

Porous Stainless Steel—Booklet, 45 pp, provides properties of available porous metals, including Type 304 and 316 stainless steels, nickel, Monel, Stellites and other alloys. Included also are data on the various porous stainless steel filter elements and containers—some with filter areas up to 1000 sq ft—and their laboratory and plant-scale application. Micro Metallic Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 119, inside back cover

Testing Shakers—Bulletin 6454, 4 pp, describes shaping systems for testing of parts, materials and assemblies. Calidyne Co., Winchester, Mass.

Circle 120, inside back cover

Flexible Couplings—Bulletin 7, 7 pp, contains technical data such as ratings, drawings, specifications, service factors, plus information on uses of rubber-bronze bushed flexible couplings. Ajax Flexible Coupling Co., Inc., Westfield, N. Y.

Circle 121, inside back cover

Clad Steel Plates—Booklet, 6 pp, discusses 16 standard alloy claddings on a variety of backing steels. Lukens Steel Co., Coatesville, Pa.

Circle 122, inside back cover

Air Motors, Compressors, Pumps—Bulletin 1054, 11 pp, describes how 35 product component problems were solved. Contains hp requirements, air pressure or vacuum used, rpm ratings and other data. Cast Mfg. Corp., Benton Harbor, Mich.

Circle 123, inside back cover

Electrical and Electronic Glass Products—Catalog NP-54, 33 pp, describes capacitors, resistors, glass bushings, rectifier tubes, fused silica, instrument windows, seals, attenuator plates, delay lines. Corning Glass Works, Corning, N. Y.

Circle 124, inside back cover

Flame Failure Guard—Bulletin 523, 4 pp, covers working principle in detail, along with a diagrammatic sketch of an installation. Ess Instrument Co., Bergenfield, N. J.

Circle 125, inside back cover

Motors of 1/200 to 1/40 Hp—Catalog F 4271-5, 4 pp, describes unidi-

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THREE "LINES OF DEFENSE" assure absolute safety of every Solar "Mars" gas turbine engine. First, the governor holds the engine at rated speed (36,400 rpm in the unit pictured above). Second, overspeed and overtemperature shutdowns take over if the normal control system should fail. Third, *physical limitations in the engine itself* prevent ruinous overspeeds.

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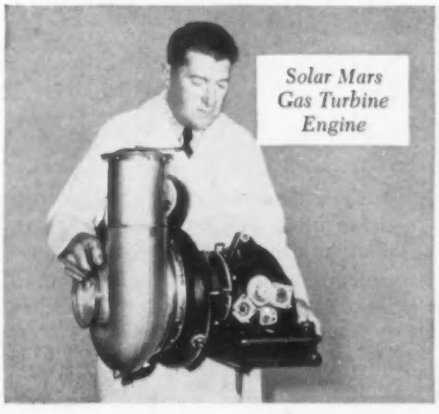

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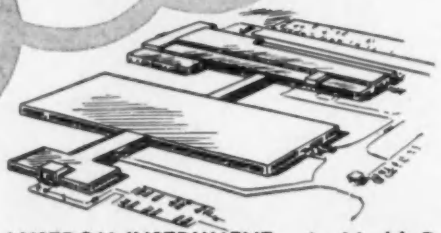

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rectional motors available in nine power ratings. Also describes other types of unidirectional synchronous, reversible, and geared head, shaded pole motors with ratings up to 1/20 hp. Barber-Colman Co., 1200 Rock St., Rockford, Ill.

Circle 126, inside back cover

Nickel Cast Irons—Bulletin A-69, 28 pp, presents characteristics of nickel cast irons in 27 useful tables, charts and photomicrographs showing how through the use of nickel, alone or in combination with other alloying elements, the engineering properties of cast iron can be controlled to meet service requirements. International Nickel, 67 Wall St., New York 5, N. Y.

Circle 127, inside back cover

Temperature Equivalents—Pocket-size chart of Fahrenheit and Centigrade equivalents is 8½x3½ in. Moeller Instrument Co., Richmond Hill 18, N. Y.

Circle 128, inside back cover

Porous Fluorocarbon Filter—Booklet, 6 pp, describes several basic types of filters, gives data on pore size, particle size removal and flow capacity. Porous Plastic Filter Co., 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 129, inside back cover

Screw Inserts—Bulletin 715-A, 4 pp, contains selection tables, line drawings showing proper installation in blind and through holes. Heli-Coli Corp., Danbury, Conn.

Circle 130, inside back cover

Instrument Parts and Components—Catalog, 64 pp, describes precision shafts, gears, collars, couplings, differentials, breadboard equipment. All items are dimensioned for design and detail layout and tolerance specifications are included. Pic Design Corp., 160 Atlantic Ave., Lynbrook, N. Y.

Circle 131, inside back cover

Copper Alloy Strip—Bulletin 5, 4 pp, presents general information on precision-rolled beryllium copper, phosphor bronze, nickel silver, chromium copper and copper strip. Describes material furnished to close thickness tolerances (±0.0001 and ±0.0002 in.). Includes discussion of available alloys, sizes and tolerances together

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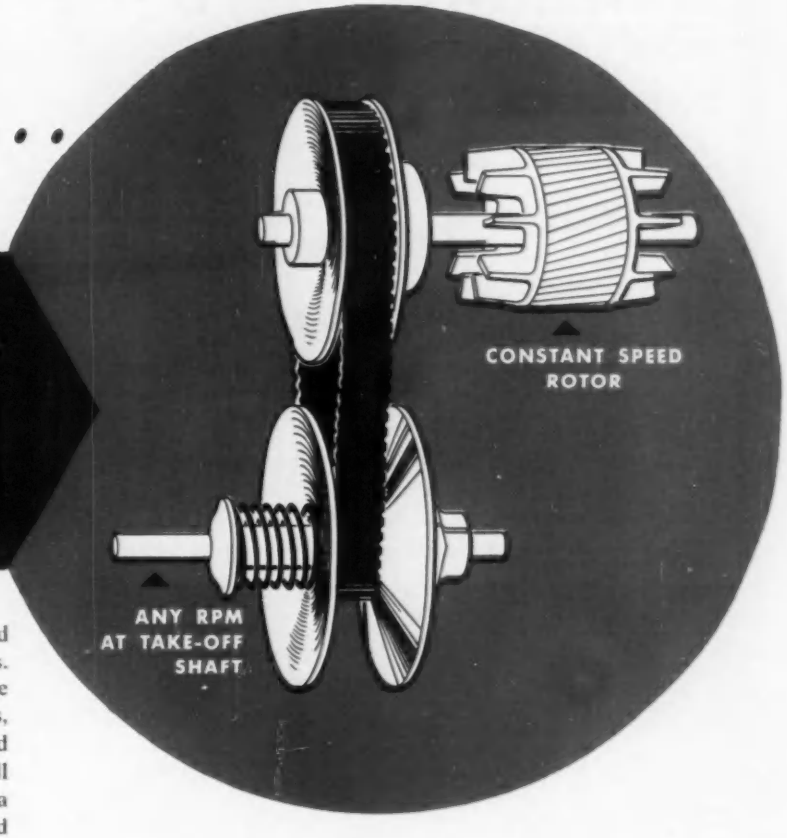

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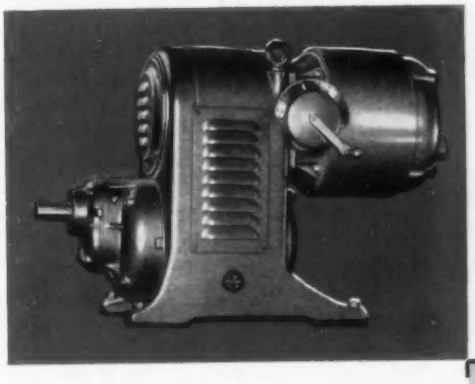

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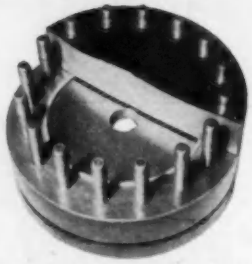

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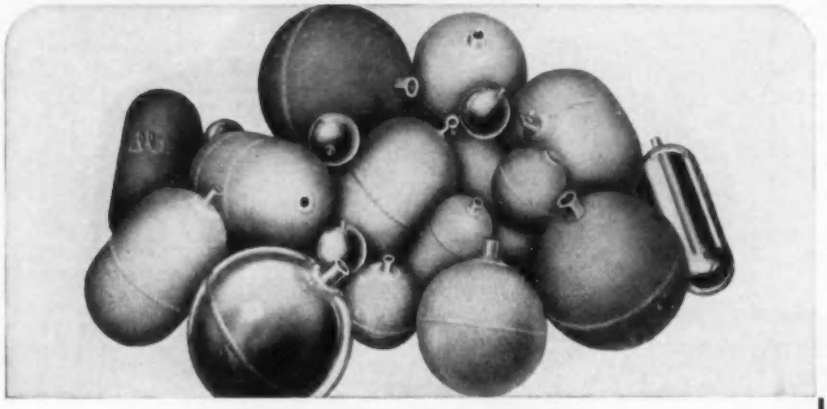

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with tabular data on engineering properties. Penn Precision Products, Inc., 501 Crescent Ave., Reading, Pa.
Circle 132, inside back cover

Air Line Filters, Lubricators, Regulators—Bulletin 65-1, 6 pp, gives schematics of air lines, cross-sectional drawings, tables of dimensions and capacities. Keller Tool Co., Grand Haven, Mich.
Circle 133, inside back cover

Valves—Charts give facts on more than 80 valves manufactured by this firm. For example, solenoid-operated valves are detailed as to type, size, operating, proof and burst pressures, operating temperatures, use, flow, solenoid electrical data, material, packing and weight. All valves listed are zero leakage types developed especially for aircraft and guided missiles. Futurecraft Corp., Dept. F-2, 1717 N. Chico Ave., El Monte, Calif.
Circle 134, inside back cover

Zinc Die Castings—Folder, 4 pp. Manufacturer contends that it is possible to produce small quantities of die castings economically. Folder points out that on 40 designs produced, tooling averaged $530. Page & Hall Mfg. Co., Inc., 1249 Farmington Ave., W. Hartford 7, Conn.
Circle 135, inside back cover

Fasteners with Pre-assembled Washer—Brochure TL97, 4 pp, shows in cross-section how the neoprene washer flows under pressure to conform with concave and convex surfaces to provide air and water-tight seal. Townsend Co., New Brighton, Pa.
Circle 136, inside back cover

Thermostats—Bulletin, 2 pp, describes thermostats for electronic and avionic devices, appliances and apparatus. Hermetically sealed and semi-enclosed styles are covered. Also gives schematic diagram performance, data, ratings, dimensions, construction details. Stevens Mfg. Co., Inc., Lexington and Mansfield, Ohio.
Circle 137, inside back cover

Synchronous Motors—Bulletin PB-110, 8 pp, covers line of synchronous, clutch unit and dual motors for instruments and controls. Includes cutaway views, dimension diagrams, speed ranges, shaft details, construc-

tion schematics. R. W. Cramer Co., Inc., Centerbrook, Conn.

Circle 138, inside back cover

Wire and Cable—Bulletin 19-354, 11 pp, contains application, product and technical information on wire and cable for machine tools, appliances, traffic-control, station-control, electric equipment applications for electrical contractors, plant electrical engineers and product designers. General Electric Co., Bridgeport 2, Conn.

Circle 139, inside back cover

Steam Jet Vacuum Pumps—Bulletin 5-E, 8 pp, discusses application, construction and operation of these single-stage pumps, and includes performance data and sizing tables. Schutte and Koerting Co., Dept. J-P, Cornwells Heights, Pa.

Circle 140, inside back cover

Steam and Air Jet Syphons—Bulletin 2A, 24 pp, describes application, construction, operation and performance of syphons which utilize pressure energy of steam or air to pump, heat and mix liquids, gases and slurries. Included are 17 tables on suction capacities, steam consumption, operation pressures and sizes and dimensions. Lead-lined, glass, special alloy and other corrosion resistant types of syphons are described. Schutte and Koerting Co., Dept. J-Q, Cornwells Heights, Pa.

Circle 141, inside back cover

Sub-Miniature Pilot Lights—Brochure L-157, 4 pp, describes one-terminal lights for use on grounded circuits. Five different types of units are described: indicator lights of the non-dimming type, dimmer-type pilot lights (mechanical or polaroid), plastic dome-omnidirectional pilot lights, indicator pilot lights with flat plastic lenses imprinted with numbers or letters, light shield assemblies for lighting dials and instruments. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.

Circle 142, inside back cover

Metal Bellows and Hose—Catalog 145, 16 pp, gives specifications and detail information on bellows of stainless steel, Monel, brass, and bronze. Hose section provides information on convoluted and corrugated types of flexible metal hose. Applications, construc-

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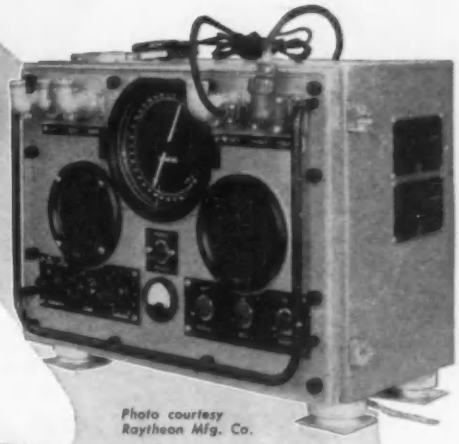

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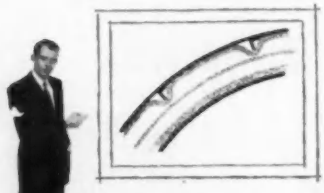

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are often used for oil or grease retention where the felt is compressed or confined in an assembly. Where operating conditions are not too severe, these grades are also used to make dust shields.

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tion, pressure, weight and standard assemblies are described. Flexionics Corp., 1351 S. 3 Ave., Maywood, Ill.

Circle 143, inside back cover

Film-Type Heating Elements—Folder contains publications describing sprayed-on heating elements. Data is included on heating problems due to odd contour shapes, space or weight limitations, lagging. Electrofilm, Inc., Dept. H., P. O. Box 106, N. Hollywood, Calif.

Circle 144, inside back cover

Vacuum Tube Voltmeters—Bulletin (4) describes miniature, panel-mounting voltmeters, auxiliary power supplies. Trio Laboratories, Inc., 3293 Seaford Ave., Wantagh, N. Y.

Circle 145, inside back cover

Torque Converter Couplings—Folder, 6 pp, describes units designed for use with engines developing 180-225 ft-lb of torque governed at 2000-2200 rpm or higher. Performance and engineering data is provided. Fuller Mfg. Co., Kalamazoo, Mich.

Circle 146, inside back cover

Magnetic Disc Brakes—Bulletin BK-4001, 4 pp, provides engineering drawings and tabulated data on torque ratings, dimensions. Dings Brakes, Inc., 4740 W. Electric Ave., Milwaukee 46, Wis.

Circle 147, inside back cover

Plastic-Covered Wood—Folder, 4 pp, describes material made by molding synthetic rubber over wood. Table of chemical resistance test results included. Gamble Bros., Inc., 4601 Almond Ave., Louisville 9, Ky.

Circle 148, inside back cover

High Temperature Selenium Rectifiers—Bulletin 6.401, 4 pp, lists 86 types and sizes of high temperature rectifier cells, their d-c output ratings in various single-phase and three-phase circuits. Life and aging characteristics, voltage drop, circuit formulae and constants. Protective coatings are also discussed. Fansteel Metallurgical Corp., N. Chicago, Ill.

Circle 149, inside back cover

Voltage Regulator—Bulletin T-8300, 4 pp, describes static voltage regulator for 60 cycle, a-c alternators. Gives detailed information on construction,

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made a loud-speaker lighter . . a nuclear resonance research unit more powerful!

Here are two case histories showing interesting and somewhat unusual applications of Indiana Permanent Magnets . . one tells the story of a tiny 1/10 ounce magnet, the other the story of a massive ½ ton magnet.

Each application called for creative and imaginative thinking . . the same kind of original engineering and design thinking that is an important part of every Indiana Permanent Magnet.

Because Indiana Steel Products Company believes so strongly in the vital importance of creative and originative magnet design, it maintains the world's largest engineering staff devoted solely to the design and application of permanent magnets.

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1/10-OUNCE PERMANENT MAGNET . . This headphone set, which includes a loud-speaker only 13/16" in diameter, is used with secretarial transcribing machines, group-hearing systems, for hotel and hospital radios, in beauty salons, dental offices, broadcasting studios, airports, etc.

The headset had to be light, which called for an exceptionally light permanent magnet of high energy. Level or sound quality could not be sacrificed. The manufacturer working with Indiana design engineers used Hyflux Alnico V. Result: Indiana Permanent Magnets that weigh only 1/10 ounce.

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operation, installation and models and specifications. Leach Corp., 4441 Santa Fe Ave., Los Angeles 58, Calif.
Circle 150, inside back cover

Permanent Magnetic Pulleys—Bulletin PY-260, 8 pp. The bulletin includes diagrams, performance data, specifications and a guide for selecting proper size. Homer Mfg. Co., Inc., Dept. 145, Lima, Ohio.
Circle 151, inside back cover

Weight and Tension-Indicating Instruments—Brochure, 4 pp, pictures and describes hook scales, tensiometers, crane weight indicators, lift-truck scales, logweighers, load cells, check valves and stroking diaphragms. Martin-Decker Corp., 3431 Cherry Ave., Long Beach 7, Calif.
Circle 152, inside back cover

Standard Cast Shapes—Catalog has dimension drawings and tabular data describing 3,000 standard metal castings. Rounds, flat round discs, gear blanks, hexagons, bushings and tubes, rings, channels, tees, angles, squares and flats, surface and lapping plates, straight edges and parallels are included, all from ready-made stock in brass, bronze, aluminum and Standardite metal. Some of the licensed foundries listed are also equipped to furnish standard shapes in ductile iron and other well known metals. Standard Foundry Products, 220-4 W. 42 St., New York 36, N. Y.
Circle 153, inside back cover

Infinite Control Switch—Bulletin, 4 pp, describes a 118- and 236-v heat control, giving switch specifications and complete operating details. Proctor Electric Co., 3 St. and Hunting Park Ave., Philadelphia 40, Pa.
Circle 154, inside back cover

Insulation Testing—Booklet, 27 pp, describes a d-c overpotential testing method. Contains a compilation of information on the principles involved and a bibliography on testing techniques. In addition, the publication includes detailed descriptions of testers which have outputs from 30,000 to 150,000 v, dc. Beta Electric Corp., 333 E. 103 St., New York 29, N. Y.
Circle 155, inside back cover

PVC Valve and Fittings—Circular, 4 pp, provides cross-sectional drawing

NEW BACK PRESSURE RELIEF VALVE...

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For Pressures From 0 to 400 Pounds P.S.I.

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- For additional information on Type FR, and other new automatic valves in the Cash-Acme line, write our Engineering Department at the address below. To avoid delay, please include a brief outline of your pressure conditions and requirements.

Cash-Acme's Type FR back pressure relief valve automatically maintains correct pressure on the inlet side, by relieving into a lower pressure line. It is not affected by pressure variations on the discharge side. Provides protection against periodic high pressure conditions. Can be used with modification as a differential pressure regulator—holding a constant difference in pressures between valve inlet and valve outlet. Valve action is fully floating for smooth and even control. New patented "Floating ring" is unusually sensitive—gives exceptionally good closure. Large capacity in almost frictionless performance.

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Catalogs and Bulletins.....continued

and dimensions. Lunkenheimer Co., Box 360, Cincinnati 14, Ohio.

Circle 156, inside back cover

Motor-Alternator—Bulletin, 1 pp, describes 30 cycles per sec model having alternator output of 1.37 w (2.37 w from shaft). Electric Motor & Specialties, Inc., King and Hamsher St., Garrett, Ind.

Circle 157, inside back cover

Squirrel-cage Motor Starters—Folder, 4 pp, describes starters for single and polyphase motors designed to be used in both normal and jogging operation. Allis-Chalmers, Milwaukee 1, Wisconsin.

Circle 158, inside back cover

Fasteners—Booklet, 14 pp, provides dimensional drawings, tables which describe weld-nuts, pipe plugs, clinch nuts, hex nuts. Decker Mfg. Co., Albion, Mich.

Circle 159, inside back cover

Time Delay Relays—Bulletin, 12 pp, covers adjustable time delay relays for panel mounting as well as fixed and adjustable units designed for built-in applications. Cut-away and exploded views are provided and load circuit operation tables, time ranges and dimension drawings are also included. R. W. Cramer Co., Inc., Centerbrook, Conn.

Circle 160, inside back cover

Aluminum Mill Forms—Wall chart lists sizes and alloys in which rectangles, angles, channels, I-beams, tubing and pipe are available. Standard truck body and truck trailer components and extruded floor sections are included and a conversion table from old to new alloy designations is also provided. Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, Calif.

Circle 161, inside back cover

Molybdenum Disulfide Lubricant—Bulletin 103, 4 pp, lists all types of this lubricant available and describes extreme pressure or boundary lubrication in which solid lubricants perform a major function. Alpha Corp., 65 Harvard Ave., Stamford, Conn.

Circle 162, inside back cover

Unidirectional Electric Motors—Bulletin F 3959-2, 4 pp, describes per-

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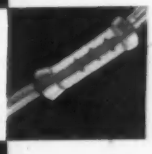
At last, a termination that pierces enamel, polyvynal acetal and similar coated wire! No more scraping, no more dipping in solvents, no more damaged wire from embrittling or solder wicking when you use new Amplivar splices. They're faster too; can be applied at a high rate of speed with AMP automatic machines. Amplivar splices are scarcely larger than the wires they connect yet mean more reliable, more uniform terminations of coil windings in your product. Positive piercing with Amplivar Keystone Serration splices assures a perfect electrical connection.



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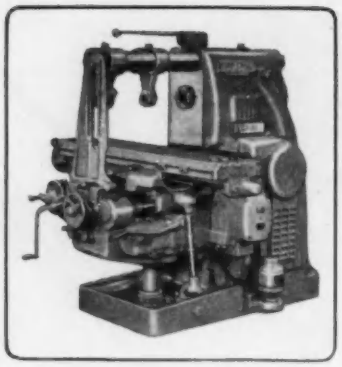

Illustrated is a Kearny & Trecker #2 Model CK Milling Machine equipped with a Gusher Coolant Pump.

From the moment you start your Ruthman Gusher Coolant Pump you get copious coolant flow. There is no priming necessary, and your Gusher Pump uses less power when throttled. Pre-lubricated ball-bearings and an electronically balanced rotating shaft assure you of low maintenance cost and trouble-free operation. Specify Gusher Pumps on your metal-working machinery.

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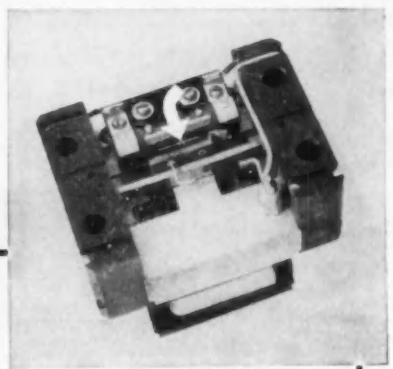

The Ney Precious Metal Contact (indicated by arrow) is an important part of this Genisco Accelerometer.

Genisco Accelerometers are used in the guidance systems of missiles now in large-scale production. They are rugged, potentiometer-type instruments chosen for their reliability and precise performance. For the double-contact wiper of the potentiometer, Genisco selected Ney's Precious Metal Alloy Paliney #7* because it provides the important advantages of holding noise at a minimum, excellent linearity, long life and satisfactory performance in temperatures from —65° F. to +200° F.

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formance characteristics of heavy duty Type YAR motors used to drive pumps, fans and blowers, record changers, vending machines and industrial controls. Barber-Colman Co., 1200 Rock St., Rockford, Ill.

Circle 163, inside back cover

Stainless Steel Mechanical Tubing—Bulletin TB-365, 6 pp, provides information on finishes, size ranges, types and shapes of available stainless tubing. Also contains a table of condensed properties and processing data for nine popular grades. Babcock & Wilcox Co., Beaver Falls, Pa.

Circle 164, inside back cover

Automatic Switches, Contactors, Timers—Bulletin, 8 pp, describes automatic electric control equipment. Zenith Electric Co., Dept. PEN, 152 W. Walton St., Chicago 10, Ill.

Circle 165, inside back cover

Pneumatic Transmitter—Bulletin Sup. 285-L2, 4 pp, describes unit designed for measuring flow, level and differential pressures in water filtration and sewage plants, and for low pressure industrial service. Contains photographs, installation diagrams and drawings. Builders-Providence, Inc., 345 Harris Ave., Providence, R. I.

Circle 166, inside back cover

Hose Couplings—Bulletin 105, 4 pp, contains cross-sectional drawings, dimension tables, installation photographs. Eastman Mfg. Co., Manitowoc, Wis.

Circle 167, inside back cover

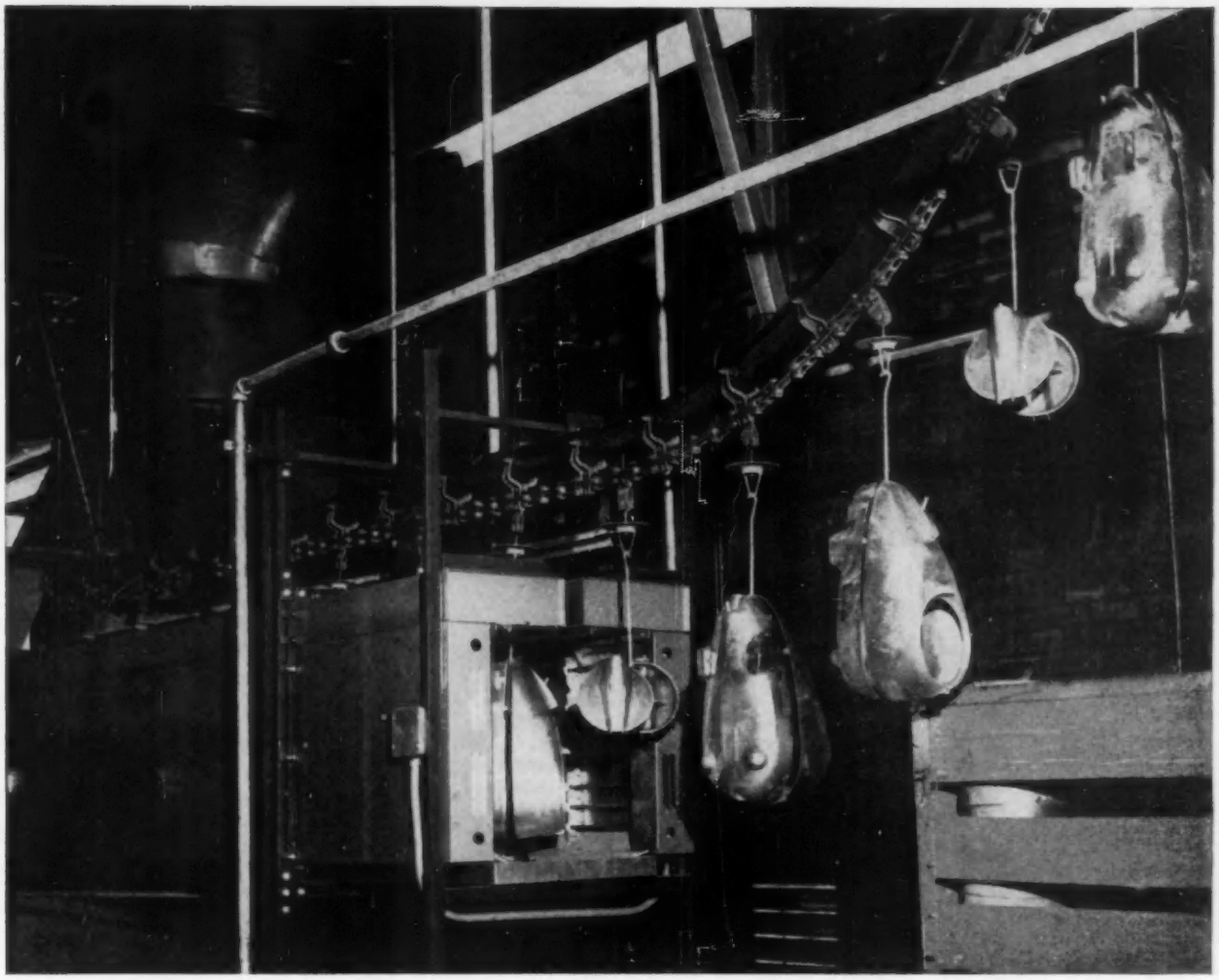
A-c Motors—Booklet, 6 pp, describes line of single-phase capacitor type and polyphase squirrel cage motors. Brooks Motor Corp., 3555-57 W. Peterson Ave., Chicago 45, Ill.

Circle 168, inside back cover

Level Indicators—Folder, 4 pp, contains engineering drawings and specifications on four models of a device consisting of a 1/200 hp motor turning a paddle wheel at 5 rpm. Material in bin or tank touching paddle stops it, operating limit switch. Convair, 712 Brookline Blvd., Pittsburgh, Pa.

Circle 169, inside back cover

Armored Motors—Bulletin GEA-4654C, 19 pp, provides information on performance and maintenance fea-



radiant pre-heating before painting reduces baking time to only 6 minutes

To speed up and modernize wrinkle finishing of vacuum cleaner parts, this company required a continuous assembly line production . . . with no stops or slow downs for degreasing, drying, spraying or baking.

Chromalox automatically controlled electric heat solved the problem right down the production line. Heating elements to heat the degreaser . . . far-infrared radiant heaters to pre-heat the work *before* painting . . . heating elements to heat the paint before spraying . . . far-infrared radiant heaters to rapid bake the finish.

Results are automatic, constant production speed . . . uniformly cured finish . . . and a reduction in baking time from a pre-calculated 20-minute period to an actual 6-minute period.

This problem-solution-result approach has enabled us to help many manufacturers produce better, faster, at lower cost.

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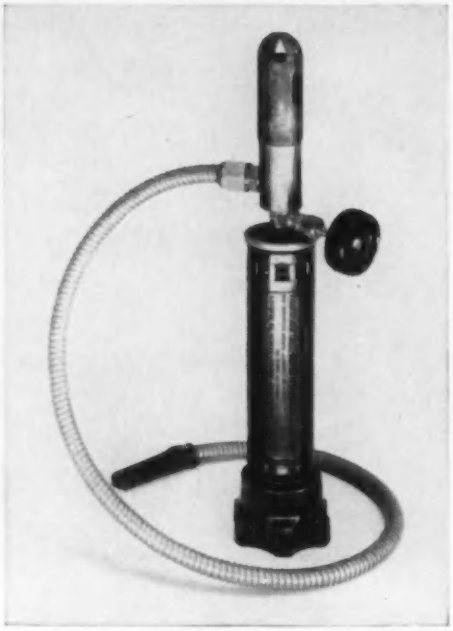
FLEXON METAL HOSE *Design Briefs*

Cost and Assembly Bottleneck on Refrigerant Leak Detector Broken with Flexon Metal Hose!



This device is used to test for Freon leaks in refrigerating systems. The Flexon Metal Hose is used as a syphon hose to reach inaccessible areas and bring up an air sample. The leak detector analyzes the sample for the presence of Freon which would indicate a leak in the system. The unit is manufactured by Just Rite Manufacturing Co., Chicago.

FLEXON
The Complete Line for the Designer

REX-WELD corrugated metal hose in steel, bronze and alloys; sizes 3/16" through 24", I.D.; for burst pressures to 12000 psi.

REX-TUBE interlocked, square locked and ball bearing type hose and tubing in steel, bronze, stainless steel and other alloys; sizes 3/16" through 12", I.D. for low and moderate pressures and for use as conduit, ducting, exhaust, protective armor, etc.

DESIGN GUIDE No. 145 gives basic specifications and application data for Flexon Metal Hose. Write for your copy, today.

The designer's problem on this leak detector was to reduce cost and simplify assembly. The answer was found in using steel Flexon Rex-Tube Type RT-13 for the syphon hose. Rex-Tube Type RT-13 is a square locked flexible tubing with heavy asbestos packing. The use of Rex-Tube not only reduced cost and simplified assembly but provided a hose that is able to withstand hard usage better than the previous material.

If you have a design problem involving the conveying of liquids, gases or granular solids, it will pay you to consider Flexon Metal Hose. For specific recommendations, send an outline of your requirements.

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FORMERLY CHICAGO METAL HOSE CORPORATION
Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
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Flexon identifies products of Flexonics Corporation that have served industry for over 53 years.

tures of this heavy-duty mill motor. Included in the bulletin are horsepower ratings and mechanical data. General Electric Co., Schenectady 5, N. Y.
Circle 170, inside back cover

Peelable Plastic Packaging—Booklet, 12 pp, outlines application of butyrate peelable plastic in the hot melt dipping of parts and components. Eastman Chemical Products, Inc., Kingsport, Tenn.
Circle 171, inside back cover

Vacuum Tube Electrometers—Catalog, 12 pp, includes introductory data on electrometer characteristics, circuit discussions, seventeen connection diagrams. Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.
Circle 172, inside back cover

Tetrafluorethylene Products—Manual, 60 pp, on Teflon discusses history, general characteristics, manufacture, compositions, uses, properties, suitability to various forming techniques. E. I. DuPont de Nemours & Co., Inc., Wilmington 98, Del.
Circle 173, inside back cover

Hydraulic Equipment—Booklet, 20 pp, has drawings, specification data on hydraulic pumps, rams, valves, couplers and other types of units. Char-Lynn Co., 2843-26 Ave. S., Minneapolis 6, Minn.
Circle 174, inside back cover

Pneumatic Production Equipment—Booklet, 20 pp, contains photographs and descriptions of pneumatic feeders, fabricating units, assemblers in use in production equipment. Mead Specialties Co., 4114 N. Knox Ave., Chicago 41, Ill.
Circle 175, inside back cover

Mechanical Seals—Bulletin S-204-2, 11 pp, contains cross-sectional drawings, cutaway views, design recommendations. Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill.
Circle 176, inside back cover

Oil Burner Controls—Catalog, 8 pp, illustrates and describes line of controls for vaporizing oil-burning appliances with manual and thermostatic operation. A selection chart lists 23 different basic types of constant level valves with all thermostatic control

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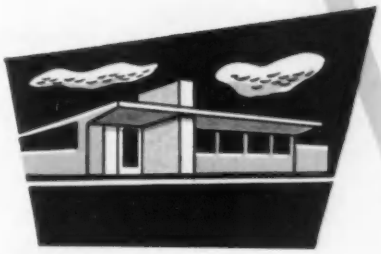


IN THE HOME

IMPELLER DISPOSER

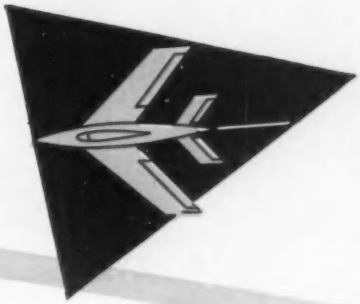
One of four Mueller Brass Co. parts in modern waste disposal unit. Completely dependable in daily operation.

WINDOW HARDWARE

Forged of natural bronze. Can be furnished in aluminum or chrome finish as desired. Retains original beauty indefinitely.

BURNER HEAD

Forged of aluminum for installation in gas stove. Lightweight yet strong.



IN AVIATION

LANDING GEAR TORQUE ARM

SUPPORT MEMBER

INSTRUMENT HOUSING

These aluminum forgings provide the same strength as steel yet weigh only 1/3 as much. Smooth bright surfaces save machining time and eliminate costly finishing.

Specially designed forged housing for sealing diaphragm in aviation pressure warning unit.

IN INDUSTRY

CONNECTING ROD

Forged from "600" series metal. Over two million connecting rods produced without recorded failure.

ACTUATING GEAR

Forged from special Mueller Brass Co. alloy. Must take constant pounding.

AUTOMOTIVE GEAR

Forged of "600" series metal for use in automotive automatic transmission. Replaced part that was giving constant trouble; solved costly problem.

All Mueller Brass Co. forgings, of which just a few are shown here, have a dense, close-grained structure with a high tensile strength. Weight savings up to 40% are possible in the design of parts because of the close tolerances to which they can be produced. Less scrap and longer tool life result from the easy machinability of forged parts. Mueller Brass Co. is completely equipped to design parts for your products, specify alloys (including special alloys developed by our metallurgists), forge, machine, finish and plate the parts and perform all necessary assembly operations. Write today for our free illustrated 32-page forgings catalog and complete information about MBCo forged parts for your products.

140

MUELLER BRASS CO. PORT HURON 17, MICHIGAN

another filter problem solved . . .

R-F NOISE REMOVED FROM ELECTRIC DRILL

Photo courtesy The Black & Decker Mfg. Co.

PROBLEM—R-F interference caused by portable electric hand tools was once quite a problem for the military. To suppress the noise from such small equipment, engineers tried outboard filters and shielded line cords. But these proved to be expensive, bulky, and generally inconvenient. In addition, leakage current from line to tool frame was increased—in some cases to a hazardous extent.

APPROACH—The Black & Decker Manufacturing Co., maker of the drill illustrated above, submitted the problem to the Radio Noise Suppression Laboratories of the Sprague Electric Company in Los Angeles.

SOLUTION—Sprague designed a tailor-made filter which meets all the requirements of size, weight, and performance. Eliminating all radio noise, the filter is still small enough to be installed in the drill housing.

FILTER PRODUCTION SCHEDULES for this drill and small electric hand tools made by other manufacturers are regularly met by Sprague plants on both coasts. Perhaps we can solve your problem too. Write, wire, or phone Sprague Electric Co., 11325 W. Washington Blvd., Los Angeles. 66, Calif. (TExas 0-7491) or North Adams, Mass. (MOhawk 3-5311).

Sprague on request will provide you with complete application engineering service for optimum results in the use of radio noise filters.

YOU CAN DEPEND ON

SPRAGUE

WORLD'S LARGEST CAPACITOR MANUFACTURER

accessories applicable to each valve included. A-P Controls Corp., 2450 N. 32 St., Milwaukee 45, Wis.

Circle 177, inside back cover

High Resistance Measurement—Bulletin, 4 pp, describes instrument for checking insulation resistance. Unit will measure up to 2 million megohm. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle 178, inside back cover

Motor Speed Control—Bulletin, 4 pp, describes unit available for motors of 1/15 to 1½ hp. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle 179, inside back cover

Steel Tubing—Catalog, 8 pp. Properties, typical applications, fabricating tips and standard sizes and specifications are provided, as well as photomicrographs. Avon Tube Div., Rochester, Mich.

Circle 180, inside back cover

Hydraulic Fluid—Booklet, 20 pp, includes a step-by-step check list for converting a system to the manufacturer's fire-resistant industrial hydraulic fluid, as well as detailed information on its properties and past performance. Monsanto Chemical Co., 800 N. 12 St., St. Louis 1, Mo.

Circle 181, inside back cover

Water Heating and Cooling Equipment—Catalog GK-954, 24 pp, provides cross-sectional drawings, curves, specification data on pumps, pump parts, boosters, fittings, valves, control systems. Bell & Gossett Co., Morton Grove, Ill.

Circle 182, inside back cover

Oil-Tight Push Buttons—Bulletin GEA-5779 B, 16 pp, contains information on product features and applications and complete ordering directions for push buttons, lights and combination units, operators, contact blocks, nameplates, stations and accessories. Also contains dimensions and outlines, plus contact ratings of all units. General Electric Co., Schenectady 5, N. Y.

Circle 183, inside back cover

Subminiature Switches—Data sheet P 96, 2 pp, describes environment-proof switches for −65 F to 180 F,

electrical rating of 30 v, dc, 2.5 amp inductive, 4 amp resistive. Maximum inrush is 15 amp. Micro Switch, Freeport, Ill.

Circle 184, inside back cover

Conveyor Belts—Catalog, 4 pp, has detailed specifications on solid woven and rubber belts. Main Belting Co., 1241 Carpenter St., Dept. 79, Philadelphia 47, Pa.

Circle 185, inside back cover

Terminal Blocks—Bulletin PB, 4 pp, describes sectional terminal blocks, including the three types of factory-installed contacts available in either factory-assembled blocks or in complete sections for user's assembly. Buchanan Electrical Products Corp., Hillside, N. J.

Circle 186, inside back cover

Flange-Mounted Permanent-Magnet Motor—Leaflet PM36-954, 2 pp, includes dimensional details on this 20-w, 6,000-rpm unit. Specification data are tabulated and performance curves given to cover relationships between torque output and input current, rpm, output watts and per cent efficiency. Dalmotor Co., 1362 Clay St., Santa Clara, Calif.

Circle 187, inside back cover

Electrolytic Nickel Powder—Specification Sheets PMS 30, 31, 32, 33, and 34 list chemical and physical properties of five grades of nickel powder. Plastic Metals Div., Johnstown, Pa.

Circle 188, inside back cover

Valves—Catalog 105, 27 pp, has a cross index, dimension drawings and illustrations. Edward Valves, Inc., 1201 W. 145 St., E. Chicago, Ind.

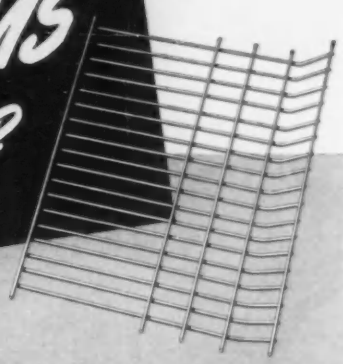
Circle 189, inside back cover

Relay Steels—Data sheets, 11 pp, includes information on applications, magnetic properties as indicated by graphs of hysteresis loops and magnetization curves and physical properties. Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa.

Circle 190, inside back cover

Hydraulic Pumps and Valves—Bulletin G, 8 pp, contains explanatory tables, drawings on a fixed displacement radial pump and on safety, relief, handwheel relief, unloading, four-way, check and

Any of these PROBLEMS Like Yours?



Had to Conserve Steel

Ice deflector assembly made by Company A for ice cube machines consisted of sheet steel, woven wire cloth and steel frame. Material shortages loomed. Told it to Titchener. Titchener designed this welded wire rack using one size of wire. New assembly proved to be sturdier — rustless — lower in cost. Additional dividends: simple tooling — fast large-scale production.

Note: Wire is more readily available during shortages. Can your product be made of wire? Ask Titchener.

Wanted Substitute for Casting

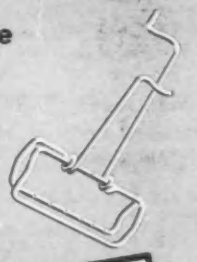
Company B, a stove manufacturer, was dissatisfied with breakage of its cast iron burner grates. Told it to Titchener. This Titchener welded-wire assembly was substituted. Result: No breakage — costs less.

Note: Wire is rigid, yet resilient. Light, yet tough. Stronger than castings or forgings. Wondering if wire can help you? Ask Titchener.

Design Was Difficult to Produce

Company C designed this complicated two-piece floor mop wire clamp. Ran into production difficulties. Told it to Titchener. Our skilled tool makers developed an ingenious method of coiling wire around itself. This made it possible to produce thousands of precision-made clamps at high speed on Titchener's forming machines.

Note: Titchener has worked hand in glove with all types of industry — large and small — in peace and war — for 65 years. How can Titchener serve you?



Tell it to TITCHENER!

If your problem involves wire forms, light stampings, welded-wire assemblies or wire-and-strip-steel items —Tell it to Titchener.

Titchener offers you . . .

- Design Assistance
- Tool and Jig Making
- High Volume Production
- Plating and Finishing
- Sample Making
- Quickly Available Materials
- Careful Inspection
- Prompt Delivery

Send us your prints — or describe your problem in a letter. Confidential. No charge for our suggestions.

E. H. TITCHENER & CO.

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Mr. L. M. Puster of our engineering staff, specialist in bellows applications.

● Whatever your problems on bellows assemblies, this specialist can give you answers that will save you time, trouble and money.

He'll know the advantages of metals to be considered for your application—brass, stainless steel, monel or nickel. He'll know the type of end fittings you should use. He'll recommend the correct bellows charge—volatile liquid or gas. And he'll give you the right advice on many other factors that will help make your bellows design plans more efficient.

Sylphon and Bridgeport bellows assemblies are used in many ways—for thermostatic devices, pressure controls, hydraulic mechanisms, expansion joints, as flexible connectors and in more applications.

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pilot-operated valves. Simplex Engineering Co., Zanesville, Ohio.

Circle 191, inside back cover

Voltage Measurement—Bulletin 2354, 4 pp, describes a portable electrical instrument for use wherever voltage must be measured over a wide frequency range. Calidyne Co., Winchester, Mass.

Circle 192, inside back cover

Permanent Magnet D-c Motors—Catalog F 4344-1, 19 pp, contains data sheets on typical motors from 6 to 115 v, dc, outputs to 1/10 hp. Barber-Colman Co., Rockford, Ill.

Circle 193, inside back cover

Line Voltage Regulator—Bulletin, 4 pp, describes distortion-free regulator for any load up to 6 kva. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle 194, inside back cover

Oil-Retaining Bronze Bearings—Stock List 4, 20 pp, lists flange, sleeve and thrust bearings, together with cored and solid bar stock. Also provides informatio non application, installation, lubrication and machining. Bound Brook Oil-Less Bearing Co., Bound Brook, N. J.

Circle 195, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

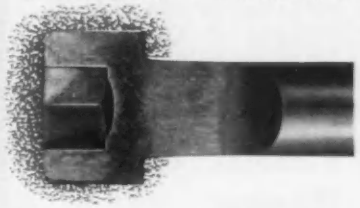
Corrosion-Resistant Valves—Bulletin 8, 8 pp, incorporates recent field-test data on various concentrations of sulfuric acid at different temperatures. Also includes a description, applications, advantages of austenitic alloy valves, together with engineering specifications and cross-sectional illustrations of thirty-nine valves and fittings. Alloy Steel Products Co., Inc., W. Elizabeth Ave., Linden, N. J.

Power Supply—House Organ, 4 pp, includes technical characteristics and articles concerning the fields of magnetic amplifiers and power supplies. Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

The BUY word for Socket Cap Screws is ALLEN

The *easy* way to make sure of greater strength, better fit and uniform quality in socket cap screws is to order "not just Allen-type but genuine ALLEN."

PRESSUR-FORMING



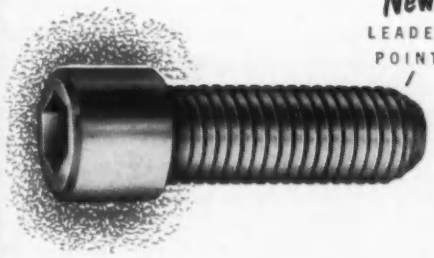
The latest improvement in the cold forging method originated by Allen. The tough Allenoy steel fibers are preserved continuous and uncut.

GRIP HEAD CAP SCREWS
The world's easiest starting, straightest driving, firmest holding cap screws.

FLAT HEAD CAP SCREWS
For firm fastening with flush surfaces. Especially adapted to fastening thin plates and sheets.

BUTTON HEAD CAP SCREWS
Produces smooth streamlined appearance where countersinking is impractical.

STAINLESS STEEL



Bright, non-corroding, high tensile strength type 18-8. 151 popular sizes (NC & NF) *available from stock.*

THE ALLENUT

Provides a ready-made threaded hole for use with cap screws in soft materials and for repair applications. Endless uses for compact design, space saving.

Sold Only Through Leading Industrial Distributors

Take advantage of their large stocks and fastener experience. Write direct for General Catalog G55.

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ALLEN HEAD

You can be sure

you're planning your production properly if you've considered the advantages of

Marblette Plastic Tooling Resins

which can speed designs from drawing board to production run, require no heavy equipment investment or highly skilled labor, facilitate pilot runs and design changes, and

will save you up to 70% in time and up to 80% in cost

in making stretch dies, draw dies and panels, match dies, jigs, fixtures, patterns, models, prototypes, core boxes, plating shields, bag and contact molds, latex dip production forms, molds for fibrous glass lay-up, spray-metal backing, vacuum-forming, and electro-forming, and other types of tools and dies.

The versatile yet specialized liquid epoxy and phenolic resins developed by Marblette fit into your production picture. Convince yourself—see how they can give you increased economy and efficiency—use the handy coupon below for resin samples, technical data, a phenolic data folder, an epoxy data folder, and a conversion computer that shows at a glance how much resin to use for casting any size product or part.

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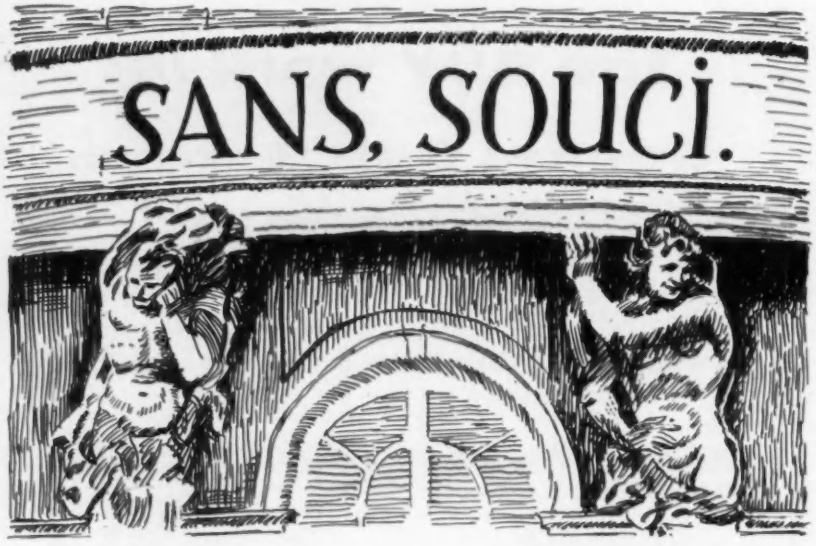


Ad Libbing by the Editor

Back in college days we had lots of fun in "bull sessions" wherein a half dozen or more students would spend a half hour or more, each one belittling all the engineering curricula except the one he was studying. The student who was studying mechanical engineering would rant about the tremendous difficulty of thermodynamics, kinematics and other courses and argue that all electrical, civil and chemical engineering courses were easy. Then an electrical student would hold forth on the terrible courses in ac and Karepetoff's awful-hard-to-understand book. And thus it went the rounds, covering all the engineering curricula.

Of course all this was in good fun. It was a game. But it demonstrated some of the interesting workings of the human mind. In the first place, every time a student wanted to "prove" that a required course was extremely difficult he always selected a course about which the other students knew nothing. Hence they were unable to question any of the glib assertions about the great difficulties encountered in trying to master the course.

So we arrive at the first fundamental principle to be applied in winning an argument. Argue only on matters about which your opponent knows nothing. Then he cannot argue back and thereby you win your case.

The second principle demonstrated is that people love to argue but only when they have a limited knowledge or no knowledge of the subject under discussion. If their knowledge were complete there would be no room for argument as the statements of the contenders would then be facts, and one cannot argue facts.

Finally, the episode of college boys arguing over the relative merits or difficulties of the respective engineering curricula they are studying illustrates the influence of ignorance. The human mind tends to belittle that which it does not know or understand.

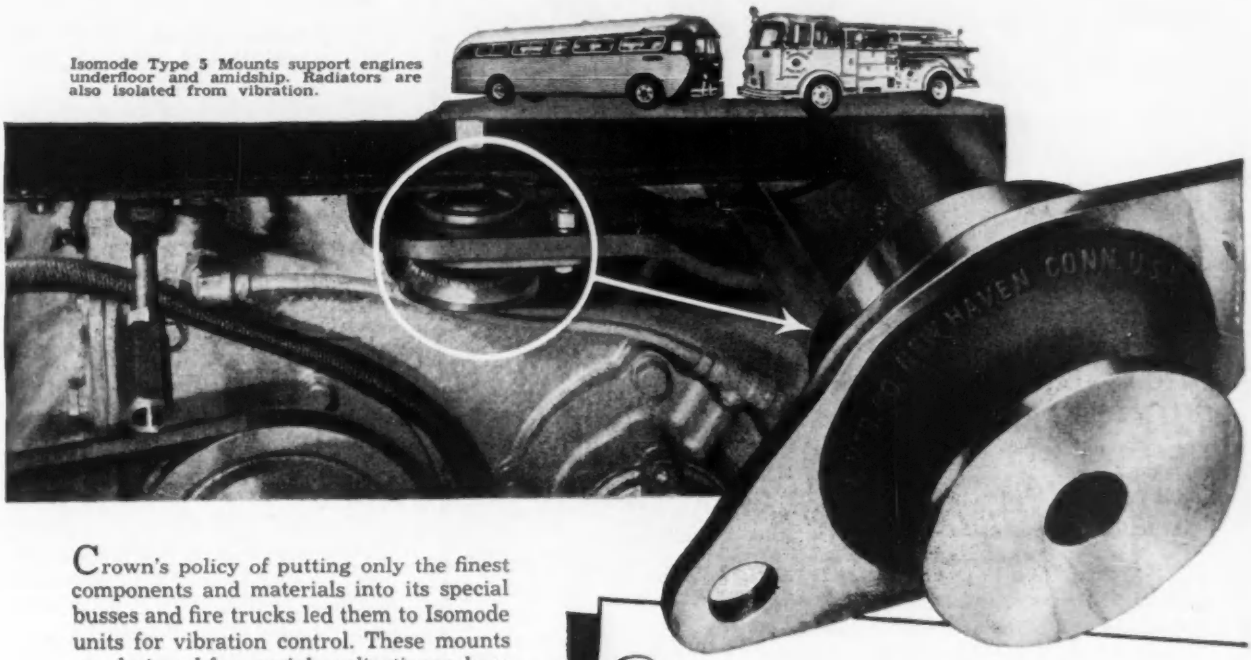
Ignorance Belittles

One might well ask, "Why is it that we are always tempted to underrate things we do not possess? Or why do we so often fail to place proper value on skills, abilities, knowledge and material possessions that are not ours?" The answer is quite simple. It is our "defense mechanism" jumping to our rescue. It saves us from the humiliating necessity of admitting to ourselves that there is something we do not have but might have had, that there is something we failed to get or that someone else has excelled us in some field or other.

Some engineers scorn salesmen and give them little credit for their persuasive abilities, mental alertness and physical activity. On the other hand, some salesmen look down on engineers and belittle their creative powers and the fund of knowledge they possess. The "practical" man may attach little value to theory, simply because he knows not what theory is. And back in the days when ignorance was rampant, cartoonists delighted in

ISOMODE® MOUNTS "...absorb vibration to a remarkable degree"

in Crown busses and fire trucks



Isomode Type 5 Mounts support engines underfloor and amidship. Radiators are also isolated from vibration.

Crown's policy of putting only the finest components and materials into its special busses and fire trucks led them to Isomode units for vibration control. These mounts are designed for special applications where performance and quality count most. From experience, Crown's choice has proved "more than satisfactory." Isomode mounts not only are tough, durable, but also absorb vibration to a remarkable degree.

In the coaches, Isomode Mounts support Hall-Scott, International Harvester, and Cummins diesel engines in amidship, underfloor installations. They also isolate radiators. They also assure smoothness in the famous Crown fire trucks designed with cab ahead of axle.

These various installations illustrate the versatility of Isomode mounts. With their design principle of equal stiffness in all planes, they isolate vibration from all directions, and work at any mounting angle.

As a principal source for special-performance mounts, MB may have the answer to *your* special vibration control problem. Contact us and see.

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September 17, 1954

The M B Manufacturing Company, Inc.
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Gentlemen:

As you know, we have been using your Isomode mounts for quite a few years in the underfloor installation of our amidship motor coach engines and for our radiator installations. The majority of engines used are Hall-Scott, International Harvester and Cummins diesel. Consistent with our policy of selecting only the finest materials available, we chose your Isomode mounts. Our subsequent experience with them has indicated they are more than satisfactory. They are tough and durable, yet absorb vibration to a remarkable degree.

Our policy of maintaining top quality has resulted in our present position as the Nation's largest producer of transit type school buses, and we also build many Airporter, Sightseeing, and Intercity coaches. The quality of your product has contributed materially to the wide acceptance of our motor coaches.

the MB manufacturing company, inc.

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HEADQUARTERS FOR PRODUCTS TO *ISOLATE* VIBRATION...TO *EXCITE* IT...TO *MEASURE* IT

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'Diamond H' Relays

Continuing development of "Diamond H" miniature, hermetically sealed, aircraft type relays is constantly widening their performance range. Now, for example, in a 4 PDT relay: sensitivity to 85 mw with vibration resistance of 500 cycles at 10 "G" and 30 "G" shock resistance; vibration resistance of 55 to 2,000 cycles at 20 "G" with 50 "G" shock resistance and maximum sensitivity of 1½ watts.

Excellent contact reliability makes "Diamond H" relays preferred choice for critical jobs in vital applications ranging from guided missiles to high speed camera equipment.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 20 "G"
Temperature Range:	—55° to + 85°C. —65° to + 125°C. —65° to + 200°C.
Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,250 V., RMS
Operating Time:	24 V. models 10 ms. or less; dropout less than 3ms.
Contacts:	30V., D.C.; 115V., A.C.; 2, 5, 7½ and 10A., resistive; 2 and 5A. inductive. Minimum 100,000 cycles life. Low interelectrode capacitance — less than 5 mmf. contacts to case; less than 2½ mmf. between contacts. Special Ratings: to 350 V., D.C., 400 MA., or other combinations including very low voltages and amperages or amperages to 20.
Operational Shock Resistance:	30, 40 and 50 "G" plus
Mechanical Shock Resistance:	up to 1,000 "G"
Mounting:	9 standard arrangements to meet all needs — plus ceramic plug-in socket.
Size:	1.6 cu. in.
Weight:	4 oz. or less

Call on "Diamond H" engineers to work with you in developing a variation to meet your specific requirements.

THE HART MANUFACTURING COMPANY
206 Bartholomew Avenue, Hartford, Connecticut

caricaturing professors and scientists and the populace applauded. Today they would censure the cartoonist.

Most of the ills of human relationships can be traced to ignorance. In personal affairs, political affairs and international affairs, ignorance stands as the greatest single barrier to understanding and is the mother of prejudice. So the next time you view or contemplate the creation of one of your competitors, be slow to criticize but be quick to learn everything possible about the product. Having done that, analyze every feature of the design and try to find out the why of it. Then perhaps you will have a little admiration for your competitor and thereby learn much of value from him. Only by learning can we gain knowledge and thereby increase our power.

Ignorance, on the other hand is the greatest impediment to human progress. The supposition is that if people are kept in ignorance it is easier to exploit them. Russian peasantry under domination of the Tsars were in that sad plight.

Fortunately, people who want to learn cannot be prevented from learning. Operations aimed at keeping such people in ignorance merely compel them to strive so much harder to gain the knowledge they desire. And in their strivings they grow stronger and stronger until finally they have accumulated the power needed to throw off the yoke that holds them.

Secrecy aims at keeping others in ignorance. It has been applied industrially to keep inventions secret. But the secret process of today is soon outmoded while the secrecy has bred lethargy and stagnation.

Of course in every business it is necessary to keep certain things secret for a time. But those are only steps on the stairs of progress. It is not expected that those little secrets will play a part in the success of the company.

Success comes from making secrets, not keeping them. The company that keeps its creation a secret for too long a time cannot profit properly on the progress it made when it developed the secret. The result is stagnation. The only way to prevent secrets from stagnating an enterprise is to make more secrets and then be so proud of them that you tell the world all about them, and then make more secrets.

—G. F. N.

ENGINEERING ABSTRACTS

Sand-Casting to Precision Finish

Abstracted from "Sperry Sand-Casts to Precision Finish," by Irving Stone, *Aviation Week*, November 15th, 1954.

Using a refined sand-casting technique, Sperry Gyroscope Co. is precision-casting microwave waveguides in a large range of configurations and sizes for itself and for other avionics manufacturers. The process gives high finishes and close tolerances, and also a considerable saving in cost. In some instances these castings are so complex as to rule out their manufacture by fabrication methods.

Highlights in the precision sand-casting technique include: all cores are made of dry sand specially processed for fineness. Rubbed between the fingers, the sand feels as smooth as talcum. Sperry's sand laboratory controls closely all core mixes of sand with cereal and resin as binders. Molds are made of either dry sand or green sand.

Special pattern equipment is used. All core boxes are aluminum alloy machined to very close tolerances and have no draft.

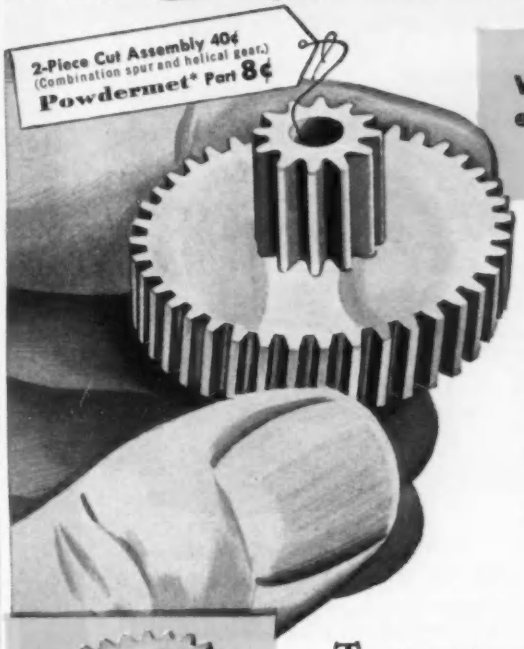
Geometrical factors are closely controlled for accurate waveguide performance. All corners are sharp; surface finish contours are held to very close limits for efficient transmission.

Pouring temperatures are closely controlled. Complete records are maintained for each job to insure reproducibility and also to build a backlog of data. Records include photos, X-ray pictures, information on sand mixes, and temperatures.

Gating and risering are permanently connected to patterns to insure that there will be no customer rejections.

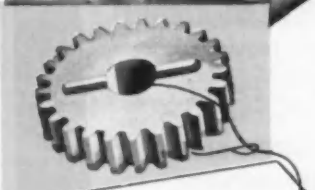
About 40 per cent of Sperry's foundry output is for the outside market, about 60 per cent of total output is for the aviation industry. Most of the waveguides for airborne work are made of magnesium, some of aluminum. Material for ground installations usually is aluminum. Bronze and copper are used where weight

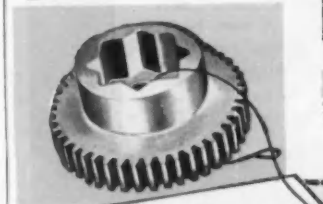
DON'T CUT PARTS ...Cut Costs!



Why pour money into expensive machining operations?

POWDERED METAL PARTS can do the job for *much less!*





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Tough, intricate parts ready for assembly without further processing—at *savings of up to 600% over identical machined parts!* No wonder industry chooses Powdermet.*

Low-cost PM parts are die-pressed to close tolerances, have excellent wearability, and a wide range of alloys are available—many exceeding the tensile strengths of mild steel. Through controlled porosity and electrical permeability, many special properties are achieved . . . such as oil-impregnation for life-time self-lubrication. That's why Powdermet* parts are often the *best parts possible* for gears, bearings, filters, etc.

At Yale & Towne, years of experience and technological know-how in powder metallurgy back up every recommendation on PM parts for *your* particular application.

YALE & TOWNE

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Powdered Metal Products Division
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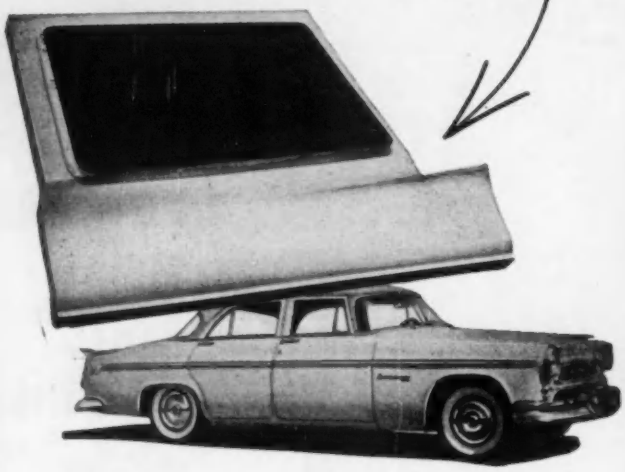
IDEAS *in the making*

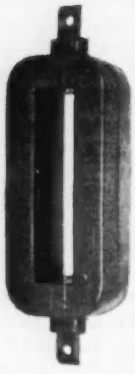
"SHAPING" THE FUTURE OF AUTOMOBILE PRODUCTION WITH ARALDITE EPOXY RESINS



PROBLEM. To cut tooling costs, achieve dimensional stability, surface hardness and reduction in weight.

SOLUTION. Impregnating, hard-setting ARALDITE Epoxy Resins further compounded provided the answer for dies of the type shown here now in regular production for Chrysler automobiles.

(Courtesy Atlantic Mfg. Co. & Chrysler Corp.)



ENCAPSULATED MAGNETIC BLOWOUT COIL FOR CIRCUIT BREAKER

PROBLEM. To develop an insulated blowout coil having high *dielectric* and *mechanical strength* and *thermal stability*.

SOLUTION. The unit was vacuum cast by I. T. E. Circuit Breaker Co., using an ARALDITE Epoxy Resin further compounded by Houghton Laboratories, Inc.

For details on Araldite Epoxy Resins formulations . . . Ciba Company Inc., Plastics Division, 627 Greenwich Street, New York 14, N. Y. or . . .

Aries Laboratories Inc. . . . . New York, N. Y.
Emerson & Cummings Inc. . . . . Canton, Mass.
Furane Plastics Inc. . . . . Los Angeles, Calif.
Houghton Laboratories Inc. . . . . Olean, N. Y.
Rubber & Asbestos Corp. . . . . Bloomfield, N. J.
Rezolin Inc. . . . . Los Angeles, Calif.

CIBA

ARALDITE® Epoxies

is of no great consideration, as in laboratory components.

As-cast internal finish on wave guides is held to 80 to 100 microinches. This is comparable to a normal machine finish after a semi-smooth cut.

Close dimensional tolerances can be maintained over a wide range of sizes from small to large—from about ½ in. to about 6 ft in length. On 1 in. length dimension, tolerances can be held to about ± 0.002 in. On lengths between 1 and 3 in., tolerance held is about ± 0.005 in. For lengths between 3 in. and 10 in., tolerance maintained is ± 0.010 in.

On a 6 ft length, tolerance can be held to ± 0.65 in. Sperry is aiming to achieve these tolerances for its general category casting jobs together with a surface finish of about 250 microinches in this casting class.

Starting cost for sand casting, including equipment (patterns, core boxes) is generally less than for other methods. It is competitive in price with other casting methods and, compared with fabricated parts, the precision sand-casting technique can produce parts for as little as 10 per cent and, on the average, for 50 per cent of the cost.

Outstanding examples of parts being cast in its precision technique includes the following: wing-folding components (three) for a Grumman aircraft. The sand casting makes it possible to eliminate all machining except drilling. The parts formerly were forged, then machined all over. The cast piece is lighter, less costly.

Fork fairing for main landing gear on an advanced fighter. This part, scheduled for casting in the very near future, is a slightly dished, rectangular surface encompassing about 350 sq in. Thickness is about 0.15 in. Surface finish is to be held to 125 microinches. Material is ZK51 magnesium alloy.

"Harmonica" antenna feed for large, long-range tracking radar. Part of a missile system, this cast piece includes 42 identical waveguide sections having common walls. Approximately 50 in. long, 8 in. wide and 2 in. thick, the dimensional tolerance for the unit, from one end to the other of the 42 guides, is approximately 0.015 in. It was found that a unit having satisfactory performance could

not be produced by fabricating a piece similar to the cast article.

Waveguide bends. These are used in various sizes in many radar applications. The units, intended for 90 deg bends, are interchangeable, can be used together with U- and S-shapes or connect with other waveguide sections. Used with a similar section, the junction of internal surfaces is so smooth that the finger can barely sense the parting line. The only machining required on these castings is on the flange faces and the drilling of pin holes for alignment.

Horn for portable test set used in calibration of X-band gun-laying airborne and surface radars. This unit, cast in magnesium, is a tapered configuration to direct microwave energy into space. Earlier fabricated unit consisted of about 10 pieces of machined aluminum flat stock requiring salt (dip) brazing. Fixture used was made of Invar, and had a short life in the salt bath—averaging one fixture for five to ten horns. Cost saving through casting the part is reported to be more than 50 per cent in small quantities, 75 to 90 per cent in larger quantities. Quadruple horns cast in one piece of bronze now replace fabricated quadruples which required 17 pieces of machined, brazed flat stock.

Serpentine shapes. Some of these use rotating joints, as in the feed for an airborne radar scanner. Formerly fabricated from bent tubing and accurately machined parts, which had to be assembled by several methods, units now are cast in magnesium at a cost saving of approximately 75 per cent.

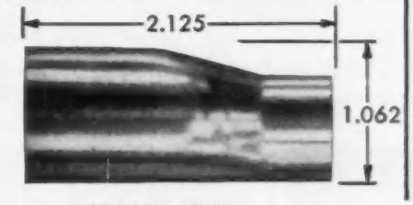
New Film Forming Materials

Abstracted from "New Film Forming Materials," by E. J. Koch, Asst. Chief, Olin Mathieson Chemical Corp., New Haven, Conn.; presented at Fifth Plastics Film, Sheeting and Coated Fabrics Div. Conference, Hotel Commodore, New York, Dec. 7 and 8, 1954.

Packaging films are becoming as varied as the products they wrap. In the cellophane field alone, there are numerous types of films modified to meet specific product requirements. The number of products being wrapped in flexible films is increasing and, in parallel with the increase, specific requirements are becoming more pronounced. These require-

This 3 Dimensional Cam Incorporates Over 1,000 Precision Dimensions!

TOP VIEW



FRONT VIEW

SIDE VIEW

PARKER CAMS MAKE POSSIBLE THE PERFORMANCE AND CONTROL OF SUPERHUMAN MECHANICAL FUNCTIONS

There are engineers with three dimensional cam problems who are unaware that their difficulties can be overcome—that Parker can design a single cam with an infinite number of exact stations—then reproduce thousands of absolutely identical duplicates to control relative motions through geometric and non-geometric curves in three dimensions.

Impossible performances are now daily routine through cam control in

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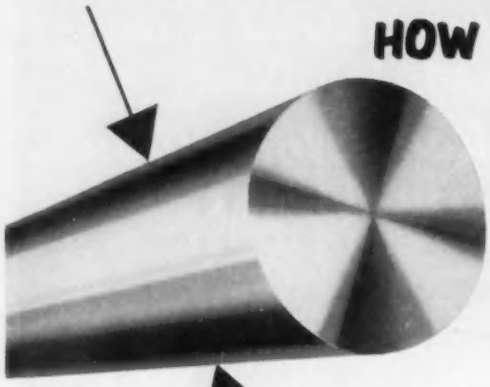
Send today for your copy of the astonishing story of a Parker-engineered cam that is the "brain center" for jet aircraft. Contact Parker for full information on how Parker cams can "think" for your machinery.

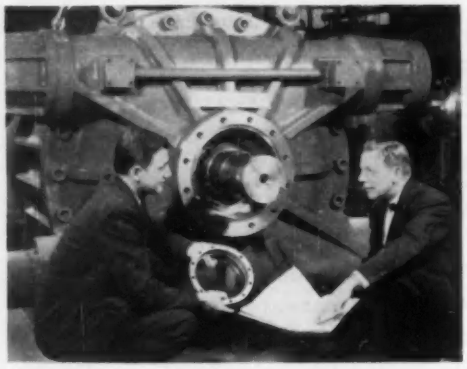
THE PARKER STAMP WORKS, INC.
CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT

by Parker



HOW BIG IS YOUR SHAFT SEALING PROBLEM?

Shaft diameter is no problem for Sealol Mechanical Shaft Seals. More and more designers are building extra operating advantages into their products with Sealol Seals of all diameters . . . from fractional inch sizes to seals many inches in diameter. Here are two typical examples.



LARGE SEAL

This Waterbury Tool Co. pump shaft (8 5/16" dia.) is sealed permanently by the compact Sealol Seal shown in the man's hand. The pump operates at a speed of 400 RPM and the pressure at the seal is 10 psi. Fluid being sealed is DTE MEDIUM oil.

SMALL SEAL

This Eastern Industries Type 104 RST pump is designed to handle water, chemicals, and other non-lubricating liquids. The compact housing incorporates a tiny Sealol Seal to seal the 1/4" shaft, rotating at 1750 RPM. Sealing pressure: up to 60 psi.

Sealol offers outstanding shaft sealing solutions. Present designs are handling pressures to 1500 psi, rubbing speeds to 15,000 fpm., operating temperatures to 500°F. The "application horizon" of Sealol Seals is constantly being extended by our research and development team. Tell us about your shaft sealing problems . . . chances are we have a workable, practical, and economical answer for them. Send details today, or ask for our new Bulletin 7.

SEALOL

SEALOL CORPORATION
177 POST ROAD
PROVIDENCE 5, R. I.

THE BALANCED PRESSURE SEAL

New York • Philadelphia • Chicago • Cleveland • Houston • San Francisco
Los Angeles • Kansas City (Mo.) • Charleston (W. Va.) • St. Louis
Tulsa • Edmonton (Can.) • Manchester (Eng.) • Paris • Frankfurt

ments include transparency, durability, purity, package machine runnability and printability.

In general, a good packaging film should be chemically inert to withstand the effects of acids, alkalis, greases, and solvents. It should be odorless and tasteless. In addition, non-flammability is desirable. Films should maintain their required properties over wide ranges of temperatures and humidities. The protective quality of a packaging film is dependent upon many properties. Notable among these are gas permeability and water vapor permeability. The degree of gas and water vapor permeability required is also dependent upon the end use of the film and may vary from extreme highs to extreme lows. It is necessary, therefore, that these properties be made to fit the requirements of specific products. For example, dried milk requires an extremely low water vapor permeability film while bananas demand a very high gas permeability film to allow for oxygen and carbon dioxide transfer.

Cost has been one of the primary factors in establishing paper, cellophane and polyethylene as the three leaders in the field. Plain cellophane is a transparent, printable, low cost film. Uncoated, it cannot be heat sealed. The durability, and gas and water vapor permeability vary greatly depending upon temperature and relative humidity conditions.

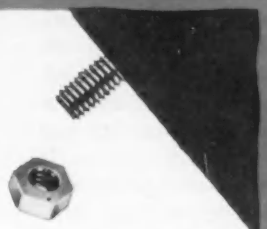
Polyethylene is a translucent to transparent, flexible, heat sealable film. It is impossible to print without special treatment. It is relatively poor in packaging machine runnability although improvements are being made. Gas permeability is high, while water vapor permeability is fairly low.

Cellulose acetate is transparent, dimensionally stable, high water vapor permeability film. It is printable but not easily heat sealed. Gas permeability is relatively high.

Rubber hydrochloride is a transparent, flexible, printable film. It is heat sealable and dimensionally stable. Its water vapor permeability is low, gas permeability high. Because of limpness, packaging machine runnability is poor.

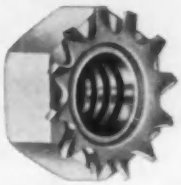
Polyvinylidene chloride is a transparent greaseproof film with very low water vapor and gas permeabilities. It is difficult to run on a packaging

Why KEPS® save time...stay tight!

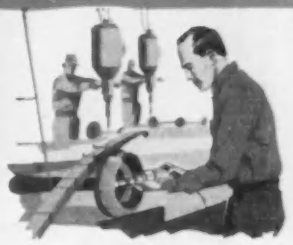


Loosening of ordinary nuts due to vibration is both dangerous and costly.

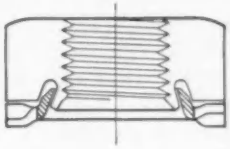
Lock washers are essential for most applications, but often hard to handle.



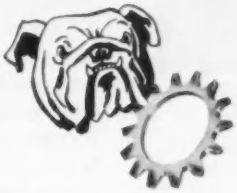
. . . except when nuts and lock washers are PRE-ASSEMBLED . . . as KEPS.



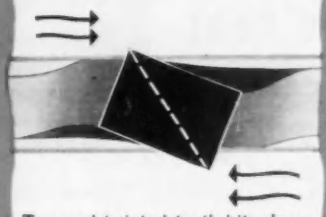
Then, awkward and costly separate lock washer handling is eliminated.



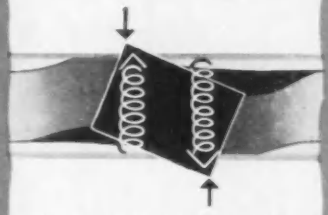
Nut and lock washer are mechanically pre-assembled as an integral unit.



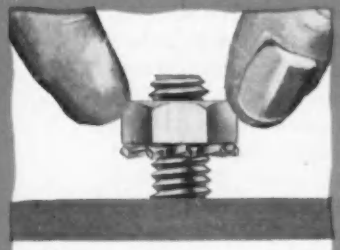
Shakeproof Lock Washers on KEPS lock tight because the teeth bite.



Tapered-twisted teeth bite deep to set up powerful resistance to any backward rotation.



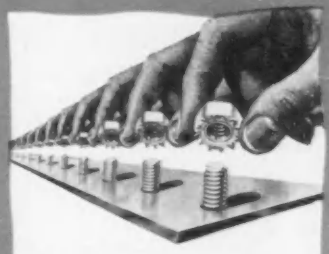
Spring tension makes each tooth bite even deeper as vibration increases.



Starting KEPS is easier . . . Free running action makes driving faster, saves assembly time.

Washers can't drop off, can't be wasted or "forgotten."

Standards and specials meet a wide variety of requirements.



With KEPS, you get tight, efficient fastening every time.

Free Sample Kit

Now . . . make your own tests! See for yourself how KEPS can save time in the assembly of your product. Write for your free sample kit today!

SHAKEPROOF

"Fastening Headquarters"®

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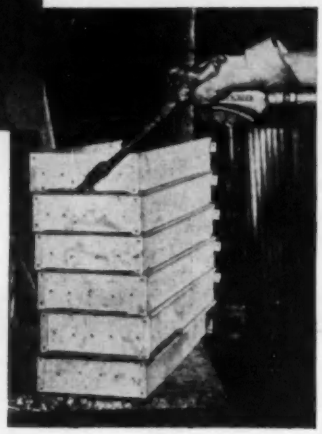
WORLD'S BROADEST LINE OF MASS-ASSEMBLY FASTENINGS

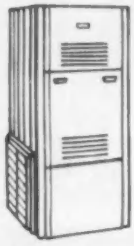
•• Elastic tape, extruded in beads, ribbons and tailored shapes, gains adhesion with aging.

Spotweld sealer on blower chute assembly remains soft and tight at high or low temperatures.



PRESSTITE

Sealing Compounds help Coleman Furnaces deliver more heat with less fuel!



To prevent costly casing leaks of heated air, which would reduce heating efficiency and increase fuel consumption, Coleman's famous Blend-Air furnaces are *sealed air-tight* with Presstite spotweld sealers and elastic tapes.

In order to transmit heated air at relatively high velocity through the ducts, static pressure must be built up in an air-tight furnace casing. Leaks would lower pressure, reduce air delivery and require extra fuel to make up the loss. By sealing the casing air-tight, Presstite sealing compounds play an important part in giving the Blend-Air owner more for his heating dollars.

Over 400 Presstite sealants protect against dust, dirt, air and water in thousands of sealing applications. Write today to learn how Presstite can meet your sealing needs, *whatever* they may be.

SEALANTS, ADHESIVES and COATINGS for

air conditioning, aircraft, appliances, aluminum windows, automobiles, breweries, bridges, cold storage, concrete curing, communications, dams and locks, excavation work, fuel tanks, greenhouses, highways, housing, railroad cars, refrigerators, reservoirs, sewers, storage tanks, trailers, trucks, and many other products and industries.

PRESSTITE SEALING COMPOUNDS

In Canada: Railway and Power Engineering Corp., Ltd.

PRESSTITE ENGINEERING COMPANY

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machine because of static and limpness. It must be electronically sealed.

Vinyl chloride is a transparent low water vapor permeability film. Like polyvinylidene chloride, it has been difficult to run on packaging machines although new developments are promising. Its properties are dependent, to a considerable extent, upon the type and quantity of plasticizer used.

Mylar is a transparent high strength film with low gas permeability and moderate water vapor permeability. It must be impulse sealed. At present, it has poor packaging machine runnability characteristics. Aluminum foil is a reflective, stiff film with low water vapor and gas permeabilities. It is printable but difficult to use in packaging machines. It is not heat sealable. It is particularly poor in abrasion resistance.

How, then, are the packaging films used today provided with the properties required for their specific end use? By means of research and development, four general types of modifications can be applied to the base film former to impart the necessary properties for a particular application. These are: (1) Modifiers in the base films; (2) physical modifications; (3) coatings; (4) laminations. In addition, various combinations of these modifications are used. Additives to the base film may be used to impart flexibility, strength, slip, an anchorage base for coatings, in the control of permeability to gas and water vapor, and to help obtain desired optical characteristics.

One of the major obstacles to the successful application of plastic films has been the difficulty in printing. Ink adhesion to the chemically inert surface has been generally poor to non-existent. In some cases this problem is being solved by treatment to the film to modify the molecular structure of the surface, thereby making it more receptive to printing inks. Such is the case with polyethylene. In product applications, where each specific product has its own oxygen requirement and carbon dioxide evolution rate, the necessary gas permeation is frequently obtained by perforating the film. Such perforations allow unlimited passage of gas in and out of the package. A second, but important, role of these perforations is to reduce the condensation of liquid

water on the inner surface of the film. Weight loss is negligibly effected by such a procedure and "fogging" is eliminated.

Coatings are used to provide varied gas and water vapor permeabilities, optical properties, slip, heat sealability, printability, greaseproofness, or as a base for laminations. Nitrocellulose and polymeric coatings, both solvent and dispersion types, wax coatings or combinations of these may be used. They may be applied on either one or both sides as required. There are also available many other materials for both solvent or dispersion systems. Plastic materials which can be used include cellulose nitrate, synthetic rubbers, vinyl acetate, vinyl chloride and vinylidene chloride copolymers. In the case of cellophane, the lacquer coating is used primarily to provide heat sealibility and moistureproofness. Polymeric coated cellophanes were developed to provide increased packaging protection in areas where normal types fell short. Greaseproofness, very low organic vapor permeability, and excellent dimensional stability are only a few of the properties improved by such coatings. In general, coating permits the use of a low cost, high strength base sheet which may be inadequate in many properties. The greaseproofness, slip, permeability, heat sealing and printing characteristics of such a film are primarily a function of the coating.

Laminations of aluminum foil with polyethylene, cellophane, cellulose acetate, and paper are widely used. In fact, it is in this area that most of the aluminum foil used for packaging is employed. Laminating adds to the foil some of the desired characteristics not inherent in the sheet itself. Laminations of polyethylene and cellophane as well as polyethylene coated on cellophane are also used.

Polyvinylidene chloride packaging films are at present limited to very special applications because of cost.

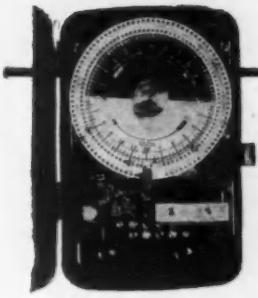
Rubber hydrochloride, although finding use in a number of applications, is difficult to use on packaging machines.

Mylar is still young in the packaging field. Because of its high strength it can be used in sufficiently thin gauges to make it a serious competitor in the packaging field. Machine developments are probably necessary.

AUTOMATIC RESET

AEMCO INTERVAL TIMERS

are engineered to excel!



CYCLE MASTER TIME SWITCH

"THE UNIT THAT NEVER FORGETS"

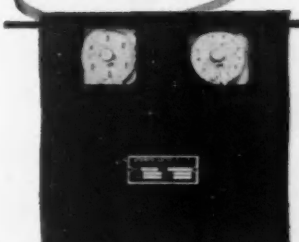
Here is a low-cost quality Time Switch that gives *more* ON and OFF operations per cycle! SPST or SPDT models are available with 24 hour cycle, 12 hour cycle, 1 hour cycle with ON or OFF intervals of as little as 15 minutes, 7½ minutes, or 37½ seconds respectively. All models will handle up to 48 ON and OFF operations during cycle. Available in 10 or 20 amp. models with 4 to 8 terminal panel, with or without Sunday-and-Holiday cutout.

MAR SERIES INTERVAL TIMERS

AUTOMATIC RESET

This neat, compact, surface mounted unit measures 6⅜" x 3⅜" x 3⅞". Has an open or exposed type dial on which settings from a few seconds to maximum cycling time may be made. Exposed terminal block for connecting either 110 or 220 volt A. C. only. The MAR Series has a 10 amp. capacity and is available with delayed action, instant recycling if current is interrupted or hold position until current is restored.

AUTOMATIC RESET



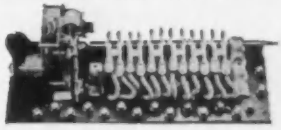
MARA SERIES

The MARA Series Timers can be supplied to operate in cycles from 10 seconds to 108 hours. In effect it is two interconnected adjustable Timers which permit varying not only the ON and OFF periods but also the length of the complete cycle. If either the open or closed circuit requires a short interval, one of the timers is provided with a very short time cycle for precise accuracy. Drawn steel case is 8" x 5" x 4½", has a lockable metal hasp and glass windows thru which dials are visible.

MANUAL RESET TIMER — SEQUENCE TIMER

MMR AND MR SERIES

A neat, compact low-cost unit for the accurate timing of a single operation, such as baking, defrosting, heat treating, etc. or for signaling purposes. Models are available in cycles from 60 seconds to 96 hours, with or without buzzer and bulls eye that visually and audibly signal end of cycle.



For accurately timing one to fifteen circuits or operations in any cycle up to 96 hours. Engineered to meet specific requirements.

WRITE TODAY to our Engineering Department for information or quotations on your specialized needs.

AEMCO Automatic Electric MFG. CO.

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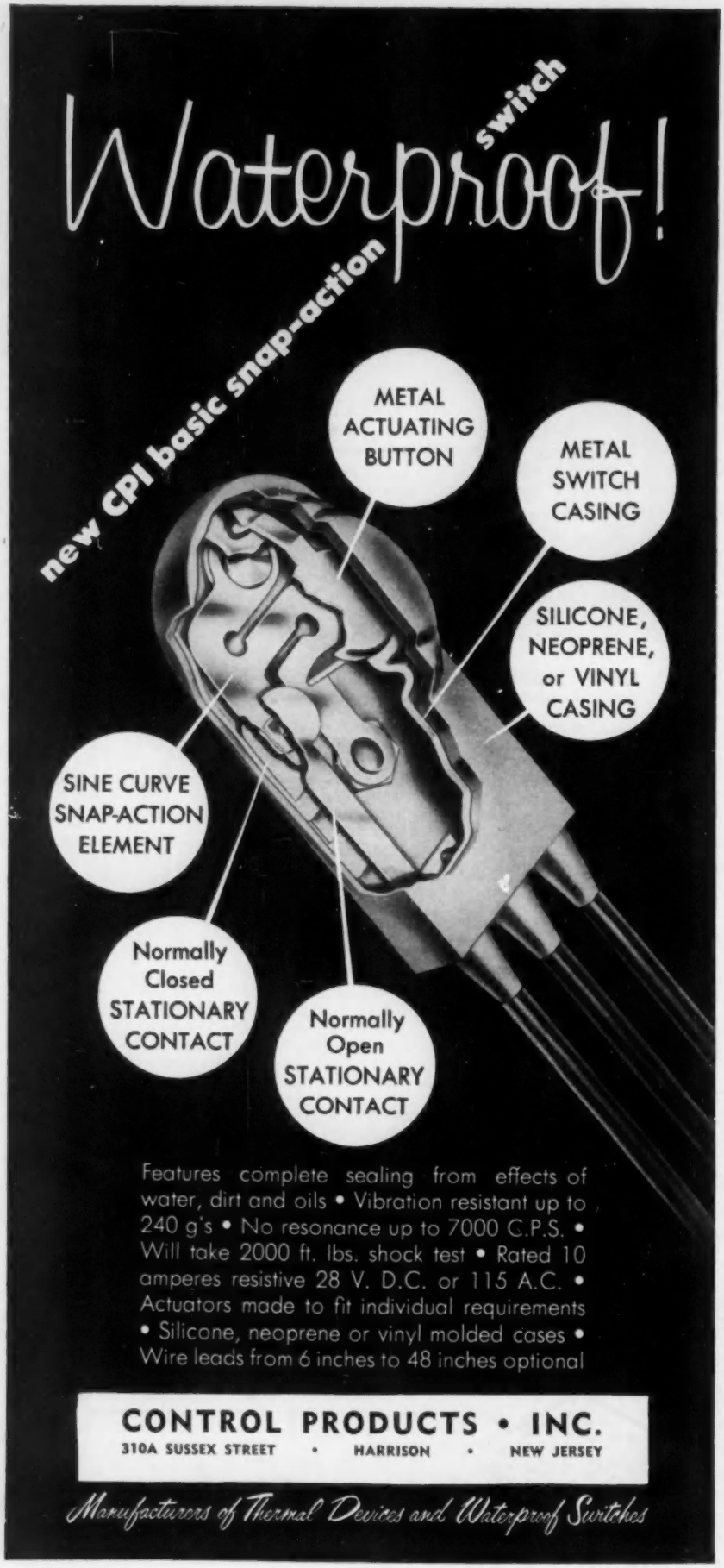
Waterproof!
switch
new CPI basic snap-action
METAL ACTUATING BUTTON
METAL SWITCH CASING
SILICONE, NEOPRENE, or VINYL CASING
SINE CURVE SNAP-ACTION ELEMENT
Normally Closed STATIONARY CONTACT
Normally Open STATIONARY CONTACT
Features complete sealing from effects of water, dirt and oils • Vibration resistant up to 240 g's • No resonance up to 7000 C.P.S. • Will take 2000 ft. lbs. shock test • Rated 10 amperes resistive 28 V. D.C. or 115 A.C. • Actuators made to fit individual requirements • Silicone, neoprene or vinyl molded cases • Wire leads from 6 inches to 48 inches optional
CONTROL PRODUCTS • INC.
310A SUSSEX STREET • HARRISON • NEW JERSEY
Manufacturers of Thermal Devices and Waterproof Switches

NEW BOOKS

Welding for Engineers

HARRY UDIN, *Dept. of Metallurgy, Massachusetts Institute of Technology,* EDWARD R. FUNK, *Engineering Consultant, Goodyear Aircraft Corp., and* JOHN WULFF, *Dept. of Metallurgy, Massachusetts Institute of Technology.* 6 x 9 *in.*, 430 *pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N .Y.* $7.50.

This book presents an analytical approach to the heterogeneous field of welding engineering which is refreshing. Although primarily a textbook for junior-level engineering students possessing a background in physics, chemistry and metallurgy, it is also good reading for practicing engineers for a broadening knowledge of welding principles.

This is not basically a "how to do it" book, but a "cause and effect" presentation. Metallurgical and chemical changes resulting from various welding methods are analyzed. To this end, principles from physics, mathematics, che mistry, metallurgy and mechanical engineering are employed in the presentation.

The present-day importance of welding as a process and the required assurance that a proposed joint design will provide adequate strength without undesirable weakening of adjoining areas makes this a most timely addition to the literature. As the authors point out, the transition from empiricism to analysis, though most important, has only commenced in the field of welding engineering.

The authors hope to stimulate interest among some readers to do graduate research which will result in more answers to further advance the science of welding engineering.

A glossary of welding terms is included as well as 63 problems relating to principles discussed in the text.

The sixteen chapter headings are as follows: The Welding Processes; Cold Welding; Hot Pressure Welding; Resistance Welding; Metallurgical Reactions in Resistance Welding; Heat and

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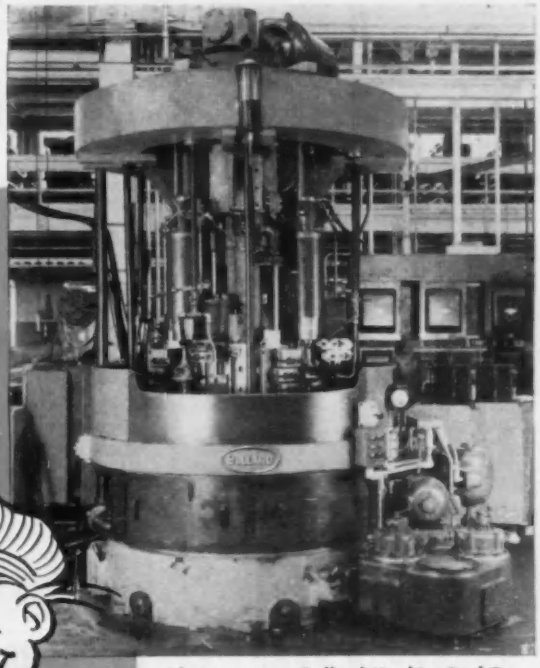

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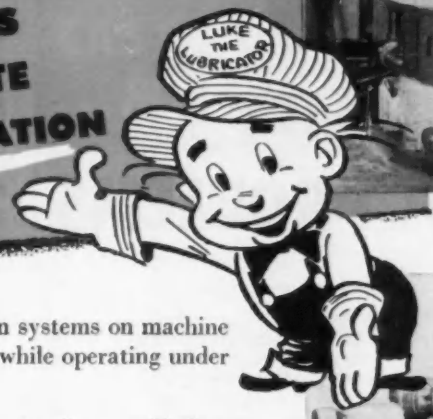

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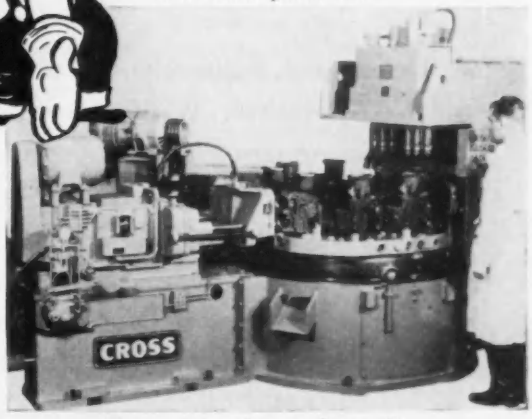

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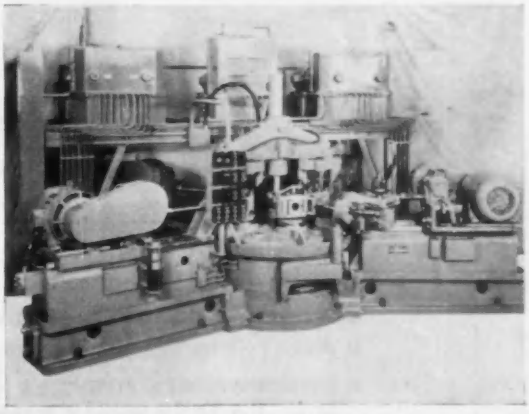

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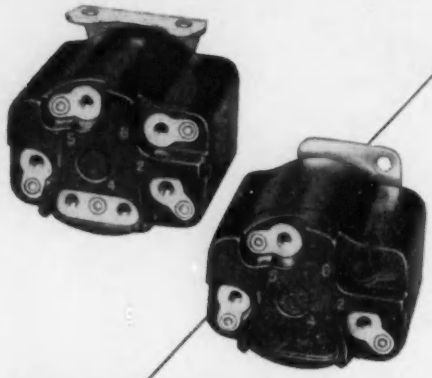

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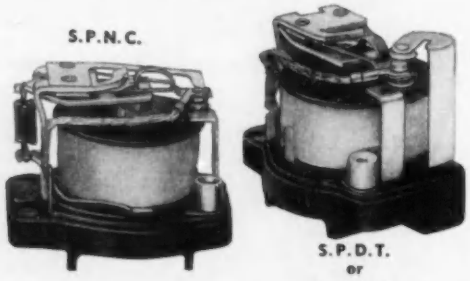

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Engineering Metallurgy

E. M. H. Lips, Dr. Ing. (Aachen), *Head of Metallurgical Labs., of the Philips Works, Eindhoven, Netherlands.* 6 x 9 *in.*, 246 *pp. Distributors for U.S.A. and Canada: Elsevier Press Inc., 402 Lovett Blvd., Houston 6, Texas.* $6.25.

As the title conveys, the subject of metallurgy is treated essentially as it is useful or necessary to the practical engineer. In these times a knowledge of the properties of the newest materials, besides the latest data on the classical ones, is indispensable in mechanical engineering design. In many branches, to mention only aircraft and engine design, the very fullest use must be made of the various qualities of a material, not only for economy, but to meet technical requirements. Technical information is presented both on the characteristic of the materials included and on their heat-treatment.

In his function as a metallurgist, Dr. Lips is in daily touch with a great range of design problems from many diverse branches of engineering, for the benefit of which his own department was created in the Philips Works at Eindhoven. He is thus in the fortunate position of knowing exactly where the designer needs the advice of the metallurgist. His daily work has revealed the need for the synthesis which he now presents. It cannot fail to be of value to all whose work entails engineering design or the applications of metals.

This synthesis of factual information should be highly useful to both practicing engineers and students. Here is a correlator of engineering design and metals development that brings the metallurgist's latest findings to

the user of metals in a highly practical form.

Chapter headings are: Mechanical Properties of Metals and Alloys; Corrosion of Metals and Alloys; Phase Diagrams and Their Significance for Metals and Alloys; Alloys of Iron with Carbon and Other Metals; Nonferrous Metals and Alloys; Heat Treatment of Metals; and The Working and Joining of Metals.

Materials for Product Development—1954

Proceedings of the Basic Materials Conference, held in conjunction with the Second Basic Materials Exposition, Chicago, May 1954. 6 x 9 in., 159 pp. Published by Clapp & Poliak, Inc., 341 Madison Ave., New York, N. Y. $7.50.

Hundreds of problems facing product designers in their selection of materials are discussed in this book, the second of a series, containing the proceedings of the Basic Materials Conference, held in Chicago last May.

Six basic problems were under consideration. These were "Materials of the Future;" "New Metal Forming Processes," such as precision castings, powder metallurgy, forging, extrusion and stamping; "Non-Metallic Materials," including plastics, carbon-graphite, ceramics and glass; "Joining," with emphasis on adhesives and adhesive bonding of metals and plastics; "Corrosion Protection," and "Materials Management," a description of how to set up and operate a materials department.

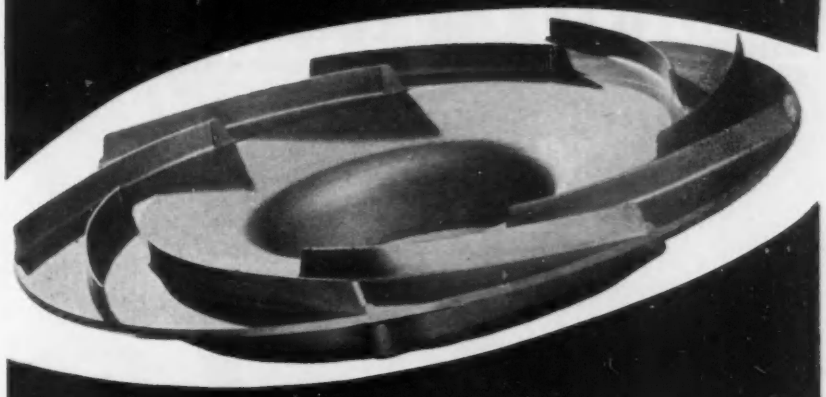
In addition to the text of the papers presented by 13 speakers, the book contains 27 illustrations, tables and diagrams, and 258 questions and answers presented at the meetings. Unfortunately, the questions are listed in the order that they were asked, thus throwing to the reader a jumbled mass of facts.

Modern Plastics

8½ x 11 in., 955 pp. Published by Modern Plastics magazine, Breskin Publications, Inc., 575 Madison Ave., New York 22, N. Y.

This new encyclopedia issue is brought up to date and presents the latest advances to individuals inter-

Lycoming and Rolle solve another casting problem . . .



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RESULTS: Fine surface finish of the permanent mold cast diffuser plates has almost eliminated costly hand buffing. And uniformly close dimensional tolerances have so simplified location of machining positions from fixed points on the casting surface that tooling has been redesigned and greatly simplified to provide even further savings.

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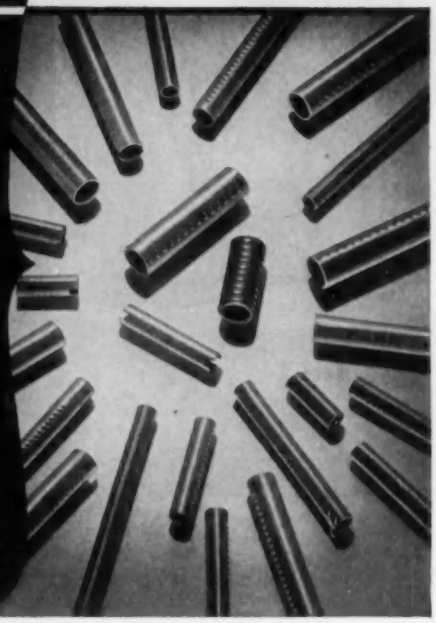

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ested in the plastics industry. It is set up in ten different sections for easy reference. The Engineering and Methods section is made up of a group of operating manuals covering the practical methods of processing the commonly used plastics.

The Fabricating and Finishing section describes the machining of laminates and thermoplastics and includes papers on welding, metallizing and decorating. The Machining and Equipment section offers information on the equipment used for each type of plastics processing.

The section on Resins and Molding Compounds presents papers on the various plastics and covers the subject of these basic materials in alphabetic order making for easy reference. One of the charts included in the encyclopedia is a wall-size Plastics Properties Chart which is on a separate sheet and not attached to the book.

The Technical Data section includes a bibliography of the literature on plastics and gives some of the industry statistics. The Directory section supplies "Where to Find It" information on the plastics materials, machinery or service.

Technical Mathematics

HAROLD S. RICE, *Head of Mathematics Dept., Wentworth Institute, and* RAYMOND M. KNIGHT, *Senior Instructor, Mathematics, Wentworth Institute, Physical Research Lab., Boston University.* 6 x 9¼ *in., 748 pp. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y.* $6.50.

Here is an introductory mathematics text written especially for junior colleges, technical institutes and other schools where students are being prepared for employment as engineering technicians equipped with the ability to apply fundamental mathematics to the problems of industry.

Arithmetic, methods of computation, intuitive geometry, classical algebra, trigonometry, periodic motion, and a brief treatment of analytical geometry and vector algebra are the major areas covered in the book.

Because of the wide range of material and subject breakdown the book can be used in varying types of technical courses lasting a year to a year and a half. To this end, the material

is divided into seven separate teaching units: I. Slide Rule and Review of Arithmetic and Geometry; II. Basic Algebra; III. Advanced Algebra and Logarithms; IV. Introduction of Analytical Trigonometry; V. Numerical Trigonometry of the Right Triangle; VI. Oblique Triangles and Applications of Numerical Trigonometry; and VII. Analytical Trigonometry. An appendix contains five place tables.

Treatment is thorough, practical, and emphasizes mathematics as an engineering tool . . . topical sequence and presentation is traditional. Vectors, periodic motion, and complex numbers are treated in more detail than is usual in mathematics texts at this level. Nearly 5,000 problems are included with many fields represented.

Shell Molding and Shell Mold Castings

T. C. Du Mond, *Editor*, Materials and Methods. 4 x 6½ *in.*, 128 *pp. Published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y., $2.*

This book should be of much interest to students and those desiring a first look at the process of shell molding. It would be helpful if there was more specific design information in a book of this type; instead, many generalities are given which will need much closer examination before an engineer can make a decision on whether to employ the shell molding process for a particular design.

Apparently, due to the newness of the process in this country, the author has preferred to present opposing viewpoints on comparative advantages and disadvantages. This is undoubtedly a good approach for students; however, more service would probably be rendered to design engineers by expert sifting of the arguments with conclusions listed.

This book can be read in a couple of hours and it should be worth this time, particularly for those relatively unfamiliar with shell molding. The book defines and gives a brief description of the process, discusses advantages and limitations, costs, materials, sizes, tolerances and finishes, some comparisons with competitive processes, equipment required and some applications. An appendix lists twenty "selected" references for further reading.

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OUR READERS SAY . . . . . .

A Pat On the Back For H. S. Teachers

To the Editor:

I read with interest your comments under the heading of "San, Souci" in the November issue. I thought you might be interested in the efforts of the professional engineers of Oklahoma in solving the problems of high school deficiencies you so ably discussed in *Product Engineering*.

The professional engineers in Oklahoma are organized as chapters and districts under the state organization, the Oklahoma Society of Professional Engineers. The Payne County Chapter, consisting largely of faculty members of the Oklahoma Institute of Technology, has initialed a movement which is outlined in the attached letter. The basic idea is to recognize those high school teachers who are doing an outstanding job in teaching high school science and mathematics. This proposal has been submitted to the state organization, which, I believe, in turn is considering presenting a similar proposal to the national organization, the National Society of Professional Engineers.

Professor Edward R. Stapley, Dean of the Oklahoma Institute of Technology, together with Professor Clemmer Wood, is conducting a survey of our entering freshman class—some 565 students—to determine their preparation previous to enrolling in college. While this survey will only include those high school students that enrolled in engineering at Oklahoma A&M College, we feel that the results will indicate the preparation our students are obtaining in our high schools.

If a sufficient number of organizations and individuals become interested, public opinion can be focused on this problem. Your approach is to be commended since it reaches so many individuals.

—J. R. Norton, P. E.
Oklahoma Agricultural & Mechanical College

Ed—Activities leading to improvement of high school technical educa-

tion such as those Assistant Director Norton describes are gratifying to hear about. The proposals being made by the Payne County professional engineering society to its state organization are described in the letter below.

"Mr. Floyd Zook, President, O.S.P.E.
Public Service Co.
Chickasha, Okla.
"Dear Engineer Zook:

"All engineers are deeply indebted to the educational institutions for the formal training which they have received. Many engineers express some appreciation to the professors who have guided them through the college courses which finally culminated in a professional career. However, most engineers have forgotten the secondary school instructors whose diligent and untiring efforts made possible such collegiate training.

"It is proposed that awards be made to high school physics and mathematics teachers for outstanding contributions to the training of engineers. These teachers in our secondary schools prepare a basic foundation upon which an engineering training must stand. A weak foundation in engineering and physical science is certainly a detriment to any engineer. An inspired teacher of mathematics or physics may certainly be the turning point in any young man's life. Too little emphasis has been placed upon the value to our society of these persons in our secondary school systems whose life has been devoted to the educational preparation of our youth.

"It is believed that if the Oklahoma Society of Professional Engineers would publicly express their obligation of indebtedness to all teachers of our secondary schools, and to the teachers of mathematics and physics in particular, those teachers would feel that some of their efforts had not been wasted.

"The Oklahoma Society of Professional Engineers, by recognizing the value of these teachers in our secondary schools, would emphasize the worth of a thorough training in mathematics and physics in our secondary schools.

"The Payne County Chapter of the Oklahoma Society of Professional Engineers, therefore, proposes that the Oklahoma Society of Professional Engineers take the necessary actions to

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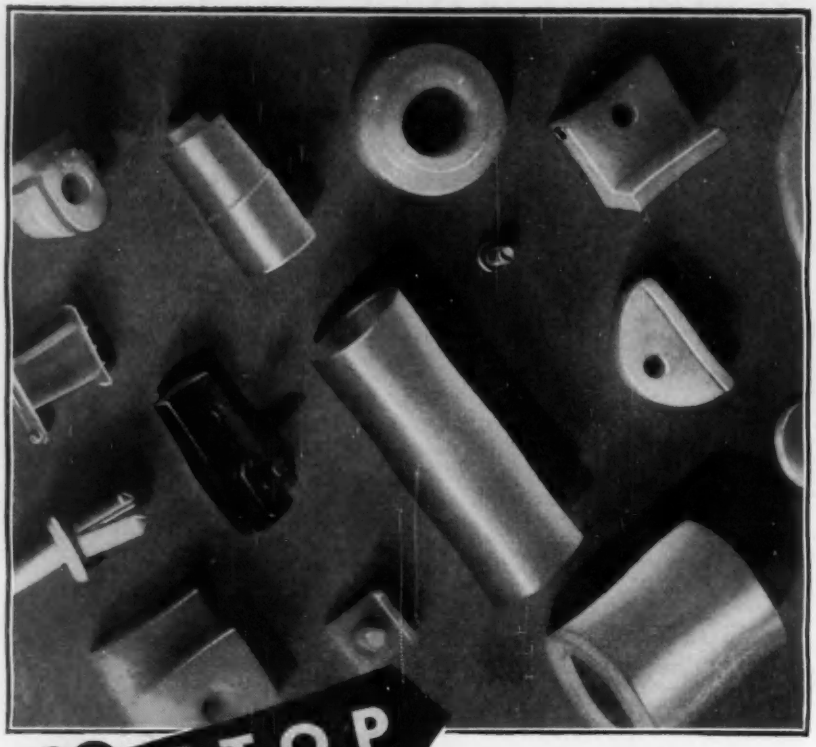

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effect properly a study of the idea and methods of carrying out a program.

"Suggested items to include in plan:

1. One award for mathematics and one award for physics be given in each of the classifications of high schools. (Class A, B, C, etc.)
2. Committee be appointed to formulate details of plan, working with Oklahoma Education Association and any other pertinent organization.
3. The award be a plaque of a type and quality suitable for display in the schools.
4. Methods of teacher nominations.
5. Fitting publicity and honor be given the teachers at the awarding, such as, bringing them to a central point for a dinner and state-wide recognition.

"This letter of proposal has been approved by the Payne County Chapter of the Oklahoma Society of Professional Engineers. We urge active consideration.

—Wilson J. Bentley, Pres.
Oklahoma Society of Professional Engrs."

Book Title

To the Editor:

We note that you list in your December issue the title of the book we published by John M. Lessells as "Strength and Resistance of Materials." It should read "Strength and Resistance of Metals." Since we have several books dealing with the strength of materials, I am afraid that your listing may prove to be a bit confusing. If it is your policy to do so, would it be possible to run a brief correction? —Rose Orente
John Wiley & Sons, Inc.

Defends Diophantes

To the Editor:

It was only yesterday that I saw in the July 1954 issue of *Product Engineering* Charles C. Foster's comment on my article on "Whole Number Solutions," that appeared in the May issue. Interesting as Mr. Foster's method is, I feel compelled to defend poor old W. Diophantes (may he rest in peace!) against some of Mr. Foster's remarks. He says: (1) that the Diophantine method is not well suited for large coefficients, and (2) that it

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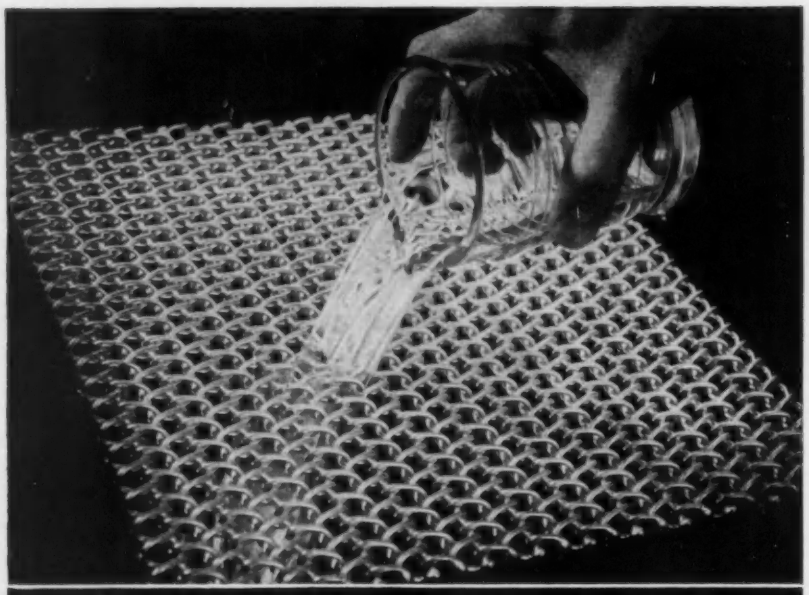

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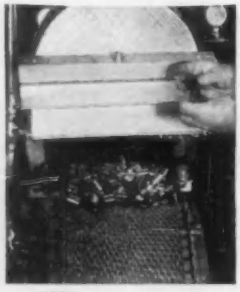

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would be even more involved than his own admittedly involved solution.

To illustrate a problem in planetary gearing he chooses an equation involving a monkey and a number of cocoanuts or vice versa and solves it, omitting a few intermediate steps, in the space of about two columns.

Just for the record, attached is the Diophantes solution of the problem.

$$1024x - 15625y - 8404 = 0$$

$$x = 15y + 8 + \frac{265y + 212}{1024}$$

$$265y + 212 - 1024u = 0$$

$$y = 3u + \frac{229u - 212}{265}$$

$$229u - 265v - 212 = 0$$

$$u = v + \frac{36v + 212}{229}$$

$$36v - 229w + 212 = 0$$

$$v = 6w - 5 + \frac{13w - 32}{36}$$

$$13w - 32 - 36p = 0$$

$$w = 2 + 2p + \frac{10p + 6}{13}$$

$$10p + 6 - 13q = 0$$

$$p = q + \frac{3q - 6}{10}$$

$$3q - 6 - 10r = 0$$

$$q = 2 + 3r + \frac{r}{3}$$

r = 3s. substitute:

$$q = 2 + 10s$$
$$p = 2 + 13s$$
$$w = 8 + 36s$$
$$v = 45 + 229s$$
$$u = 53 + 265s$$
$$y = 204 + 1024s$$
$$x = 3121 + 15360s$$

To make x and y the smallest possible positive integer, set s = 0, then x = 2121 and y = 204.

—Sigmund Rappaport
Ford Instrument Co.

Pro and Con on 1955 Annual Handbook

To the Editor:

Mr. G. M. Giannini is so pleased with the 1955 Annual Handbook of Product Design that we are enclosing request and payment for three more than our subscriptions cover. Our copies are routed and then maintained in files which date from 1939.

—Josephine K. Hagele, *Librarian*
G. M. Giannini & Co., Inc.

Ed—Sorry, the limited supply of overrun copies has already been exhausted.

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Auto-Shift combines a board and reference desk in one unit to make more effective use of space. When used in row installation, as pictured at the left, Auto-Shift puts a large reference surface and drawer directly behind each draftsman for even greater space and operating efficiency. To check reference material, the draftsman need only turn in his chair and slide the reference surface toward him. Over conventional desk-next-to-board arrangements, this Auto-Shift feature saves time and floor space.

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Auto-Shift provides convenient foot and hand releases for instant, effortless one-man adjustment of height and slope. Counterbalanced top allows finger-tip control of slope. Draftsman can change position often and yet reach any part of the board without strain whether seated or standing. He works faster and easier; production rate goes up!

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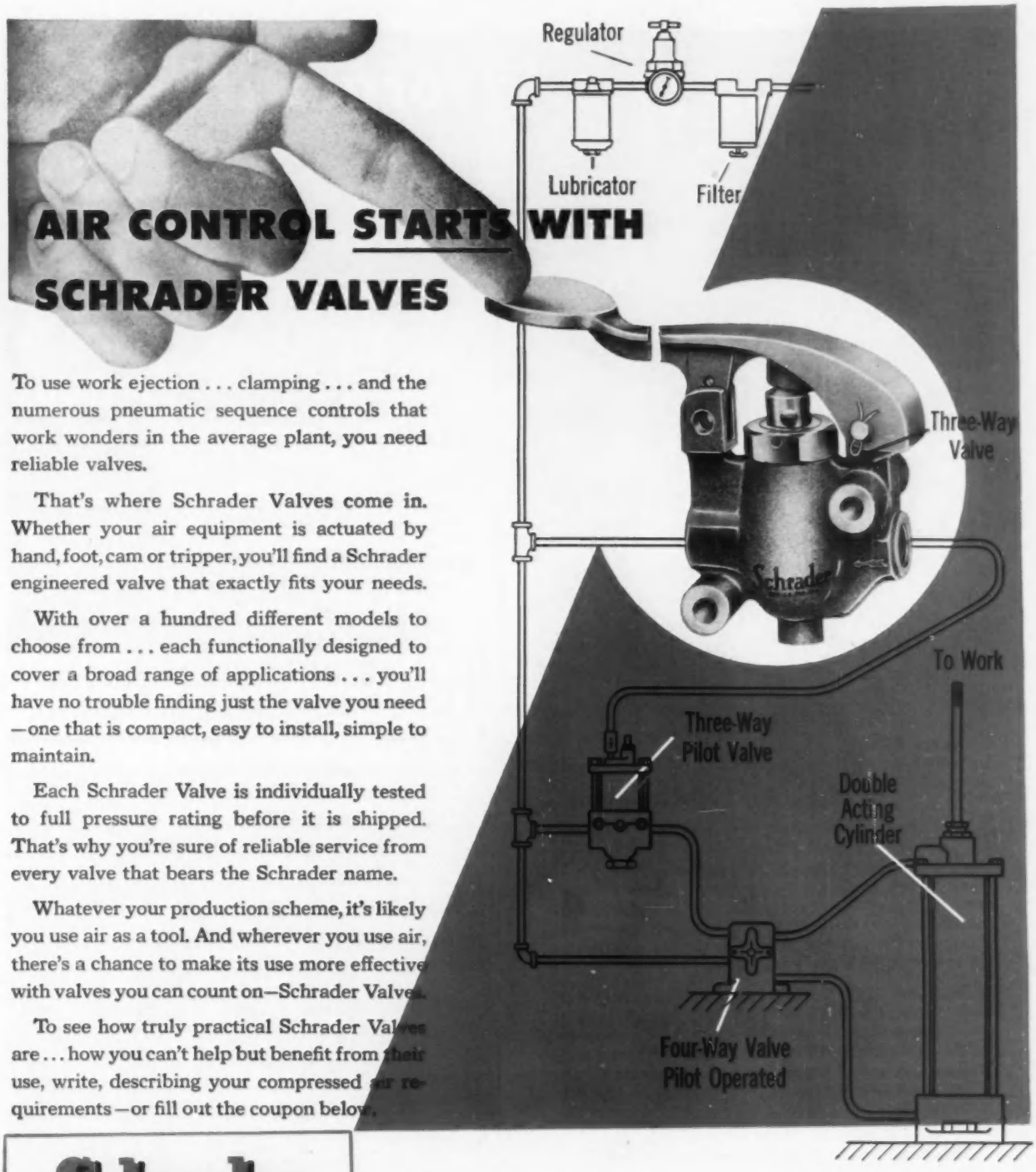

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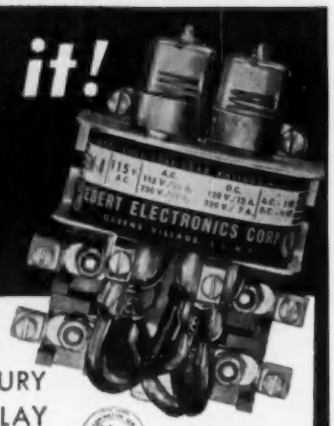

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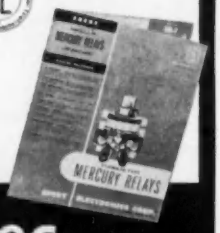

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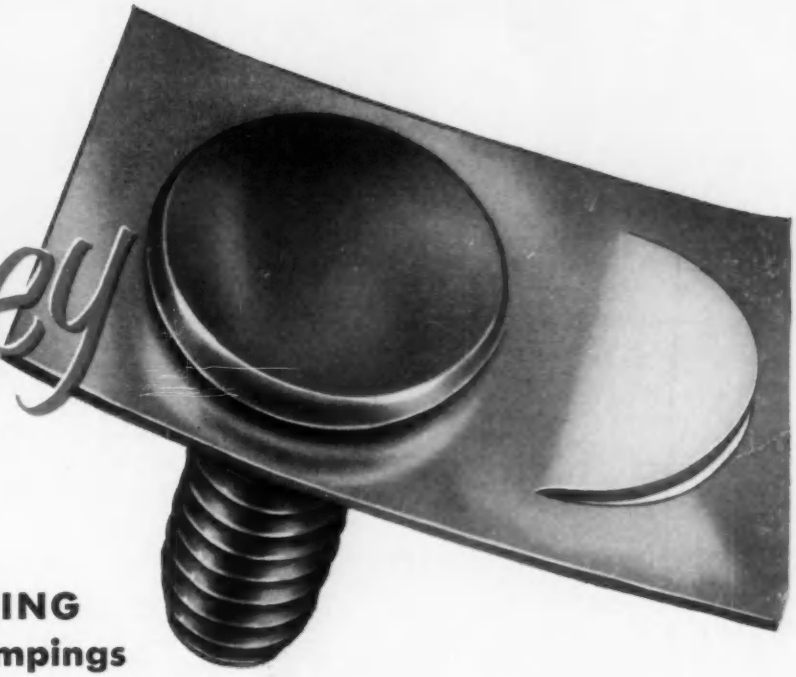

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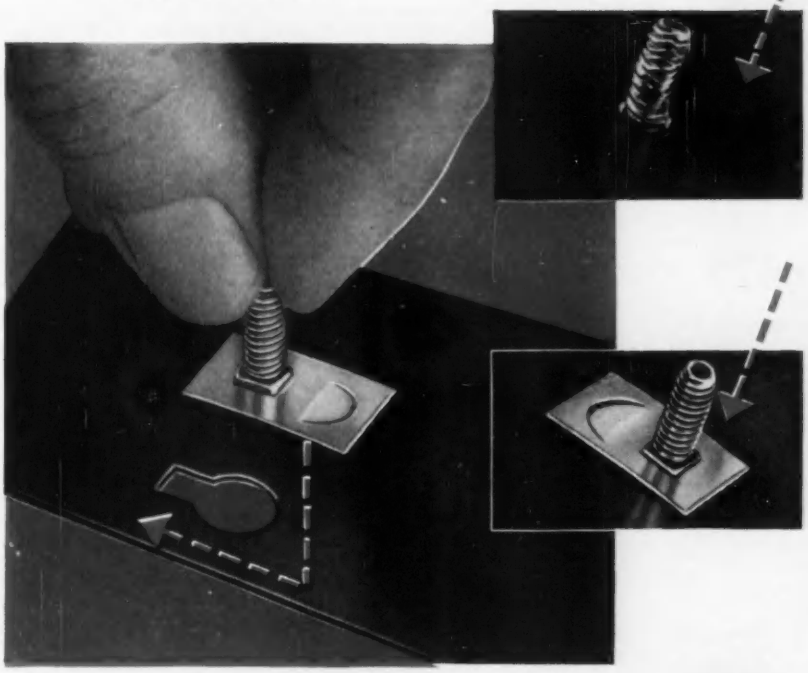
- **ELIMINATES DAMAGE due to welded or staked studs**



Not this

Welded or staked studs are easily damaged in transit from one department to the next or during processing, painting, polishing, etc. The bolts themselves can cause serious damage, denting, scratching or chipping painted or polished surfaces.

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Welded Construction
Vitreous Enameled
Height, 21"—Diameter, 24"
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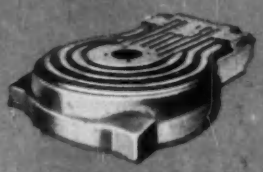

BASE FOR POWER LAWN MOWER
Seamless Drawn Steel
Length, 26"—Width, 19⅛"
Height, 4¾"

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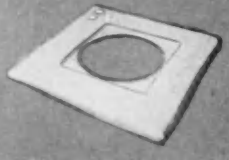
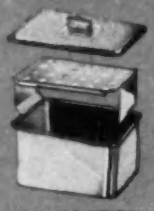
(U.S. ORDNANCE)
Carbon Steel—Spray Painted
Length, 10"—Height, 7"
Width, 3⅜"

POWER TOOL SAFETY GUARD
Seamless Drawn
Length of Cover, 29⅜"
Height of Cover, 5⅛"
Width of Cover, 10⅛"



TOP FOR AUTOMATIC WASHING MACHINE
Stainless Steel and Vitreous Enameled
Length, 26"—Width, 25"
Height, 2½"
(Also dryer tops)



SYRINGE HOLDER
Stainless Steel Box, Cover and Rack
Length, 8¼"
Height and Width, 5"

BASE FOR SWIVEL CHAIR
Seamless Drawn Carbon Steel
Length, 25"—Height, 4"

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Seamless Drawn—Vitreous Enameled
Length, 12"—Width, 10½"
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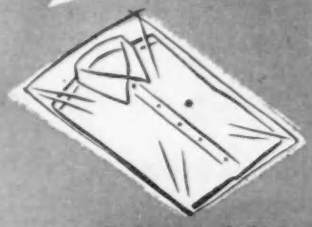
Storage bags keep their flexibility, and strength. Seams are strong, and easily stitched without fear of pulling away and ripping.

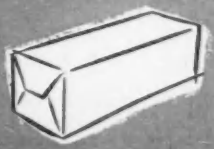


Easily heat-sealed

Seams may be heat-sealed by conventional means. This means quick convenience in retail packaging operations, plus assured dust-free and soil-free protection.

High chemical resistance

KRENE Cast Vinyl Film and Sheeting resist most acids, alkalies, alcohol, oils and greases. Drum liners protect metal drums from corrosion, make loading and unloading easy, and speed drum returns.



Laminating offers possibilities

Laminating KRENE Cast Vinyl Film to metal foil adds toughness and heat-sealability. As an inside liner it reinforces the foil and protects the metal against corrosive contents.

Are you taking full advantage of the design possibilities of KRENE® Cast Vinyl Film?

Because of the special method of manufacture, KRENE Cast Vinyl Film is different than other films you have worked with. Its unusual strength combined with remarkable clarity and gloss is unique among flexible films. In addition, chemical resistance, ease of fabrication, and other properties give you a highly versatile material for scores of uses. Increases in production have resulted in appreciable savings in cost. And its high strength and resistance to puncture and tearing offer great advantages in many applications. Why not investigate today. It's available in thicknesses from .001 to .012 in either 36 or 48 inch width. For samples of KRENE Cast Vinyl Film, and an informative booklet, write Dept. BE-10.

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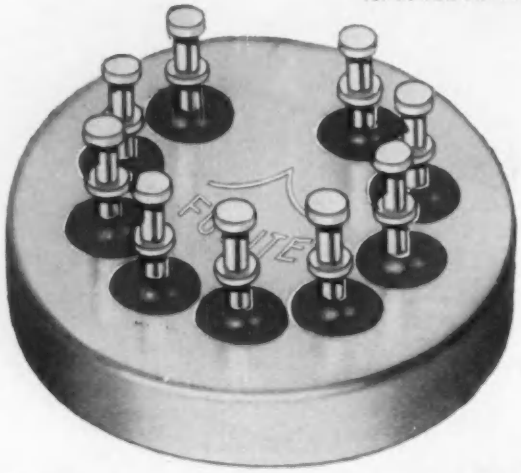

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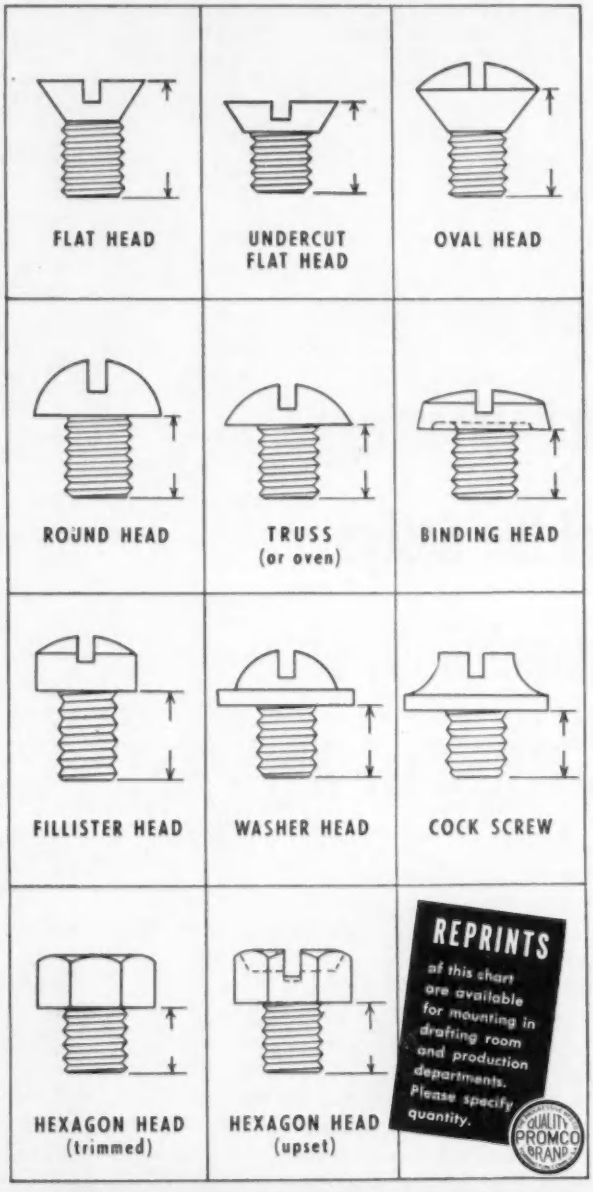

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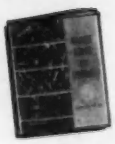

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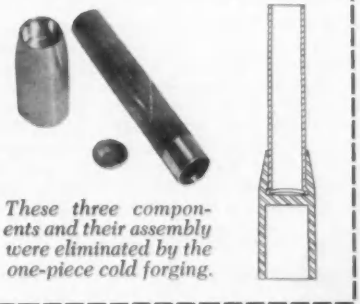
HUNTER DOUGLAS ONE-PIECE COLD FORGINGS

replace 3 piece unit, eliminate assembly, solve gas leakage problems!

A typical example of how Hunter Douglas cold forgings simplify everyday design problems

A most critical requirement in the production of an ordnance component was a perfect seal against the escape of high pressure gases. Fabrication by conventional procedures involved the assembly of three separate pieces—a screw machine part turned from bar stock and bored from each end; a separate sleeve machined from tubing, and a stamped Welsh plug. The three parts were unitized by expanding the Welsh plug within the sleeve, forcing walls into a machined groove within the head.



These three components and their assembly were eliminated by the one-piece cold forging.

To simplify the design, insure leak-proof construction and eliminate costly machining and assembly time, Hunter Douglas engineers suggested a cold forging from HD-11-T6, a high strength aluminum alloy.

All internal and external diameters of the cold forged component are now formed in a single, instantaneous press operation. No joints exist to cause leakage, consequently rejects are negligible. The cold forging, being highly stressed, easily withstands bursting pressures of 5500 psi without distortion. With its remarkable simplification in design, the cold forging requires fewer machining operations, thus saving both time and unnecessary metal waste.

Hunter Douglas Cold Forgings can be mass-produced in any required numbers and to cover a tremendous range of design requirements. If your components require *walls of zero draft, high physical properties, employ tubular shapes with or without a closed end, and must meet close dimensional tolerances,* HUNTER DOUGLAS COLD FORGINGS may provide the answer. Our engineers will give you a prompt analysis upon submission of a blueprint or sample part.

Hunter Douglas Cold Forgings cover a multitude of needs. Note wide variation in part geometry. Many complex designs formerly considered impossible to produce by cold forging now respond to new techniques developed at Hunter Douglas.

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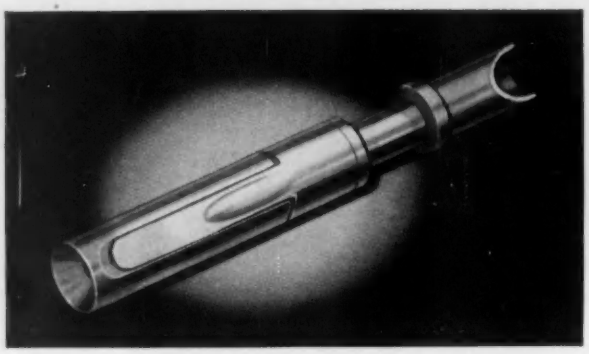

"CLIP-TYPE" closed entry socket contact now standard in

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The "Clip-Type" socket will not accept any oversize probe or pin nor can one be forced into it. Also, no amount of wrenching or twisting of an acceptable pin or probe can possibly distort the spring clip. This new socket is now standard in all Scinflex connectors including those using solderless, high-temperature and thermocouple contacts.

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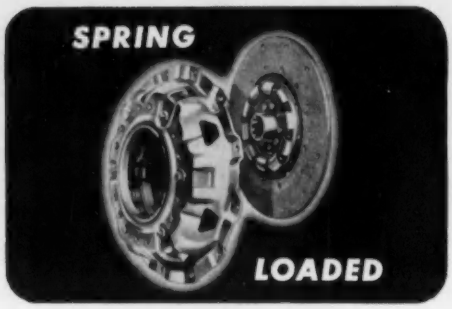

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LIFETIME ADJUSTMENT

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CLUTCHES

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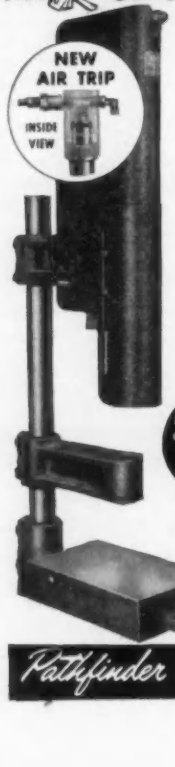

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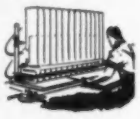
- MARKING



Most jobs done on expensive, heavy presses can *now* be done faster and cheaper by the light low-priced Mead Air Hammer using the new adjustable, spring*less* "Bullet Velocity" MEAD AIR TRIP! It delivers blows equivalent to 7½ tons down to as little as a few ounces—at several blows per second, if desired! Enjoy the *competitive benefits* of really low cost production with durable, powerful, improved Impact Air Hammer. Put Mead "how-to-do-it" experience to work for you.

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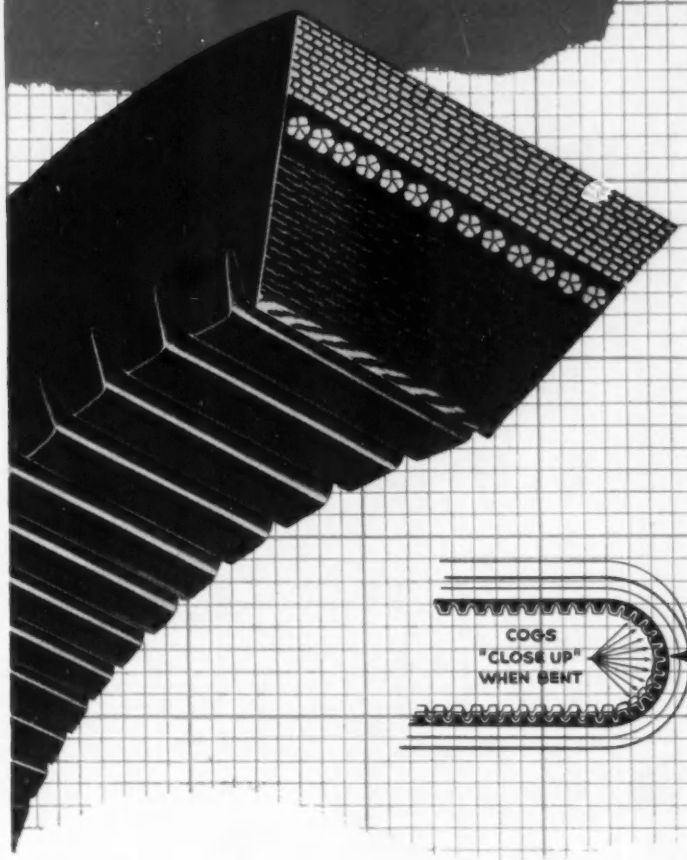
Pathfinder in AIR POWER AUTOMATION

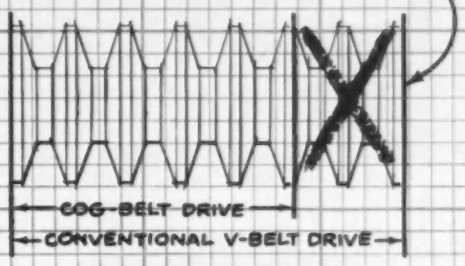
Reduce Weight by 28%

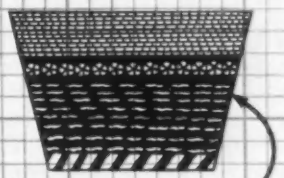
in your V-Belt drive design with Dayton Cog-Belts*



5 Cog-Belts do the work of 7 ordinary V-Belts

40% BONUS POWER PERMITS DESIGN FOR NARROWER SHEAVES, FEWER GROOVES, SAVES WEIGHT BY AS MUCH AS 28%





Special Compounds—

RESIST OIL, HEAT, DISSIPATE STATIC. BELTS NOT AFFECTED BY OIL, WITHSTAND HIGHER TEMPERATURES, DISSIPATE STATIC BUILDUP

Cog-Belts are cooler running—

LARGER SURFACE AREA OF COGS DISSIPATES HEAT FASTER

Whenever *weight* is the problem in a new V-Belt drive design, then Dayton Cog-Belts are the *solution.* You can eliminate costly, unnecessary weight by as much as 28% without sacrificing one ounce of power, impairing efficiency or shortening life of the drive! How? Dayton Cog-Belts deliver 40% more horsepower per belt from the power source. Therefore, you can specify narrower, shorter sheaves with less grooves . . . shorter and fewer belts . . . shorter center distances . . . and lighter supporting frame members for a given power application. And in addition to saving weight, you save space and cost and gain compactness and power.

What's more, with patented and exclusive Dayton Cog-Belts, you can be assured of maintaining the superiority of your finished products. Your customers will also profit by trouble-free, low-cost power transmission and increased productivity.

For help on your drive design problem, take advantage of Dayton's expert, experienced engineering staff. Write to: Dayton Rubber Company, Industrial Division, Dept. 871, Dayton 1, Ohio.

Check These Exclusive Design Advantages:

• The Tension Section flexes easily, giving longer life. • The Loading Carrying Section has maximum stretch-proof strength. • The Compression Section has unequalled crosswise rigidity. • Preformed, integral Cogs flex uniformly for full grip • Smooth, die-cut sides assure positive grip, *full* power.

Dayton Rubber
Since 1905

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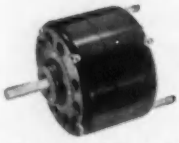
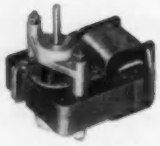
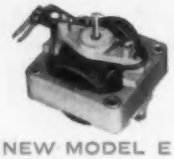


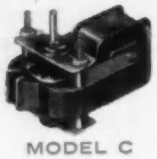
NEW MODEL B
4-pole, 4-coil shaded pole AC Induction Type



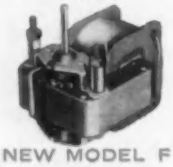
MODEL A
2-pole, shaded pole AC Induction Type



NEW MODEL E
4-pole, shaded pole AC Induction Type



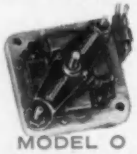
MODEL C
2-pole, shaded pole AC Induction Type



NEW MODEL F
2-pole, shaded pole AC Induction Type

MODEL D
4-pole, 4-coil, shaded pole AC Induction Type

Write for complete specifications and quantity-price quotations!



MODEL O
2-pole Capacitor Reversible Type, AC only (for 6, 12 or 24 volt)

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The versatility of Ledex Relays makes it possible to produce special switching combinations for specific applications. Stepping or selective controls are available depending upon the requirements. A wide range of operating voltages can be used by selecting the proper Ledex coil wire size.

HERE'S HOW A LEDEX RELAY OPERATES . . .

A LEDEX ROTARY SOLENOID provides the mechanical power to drive the gang of rotary, wafer type switches. SELECTIVE CONTROL —The commutating switch of the Ledex in combination with the control wafer switch makes it possible to select the multiple circuits to be connected by a single manually operated switch. RATCHETS are used to transmit the oscillating action of the Rotary Solenoid to the Relay rotor shaft. CIRCUIT WAFERS are produced in combinations of 8, 10, 12, 18 and 24 positions. All wafer sections are versatile in application. For example the 12 position wafer switch may be designed to utilize almost any of the factors of 12 such as 1P-12T, 2P-6T, 3P-4T, or 4P-3T. The clips and rotors of the wafer switches are of silver alloy. For most applications the switch insulation is of wax-impregnated bakelite. Ledex Relays are available with foot, flange or panel mountings.

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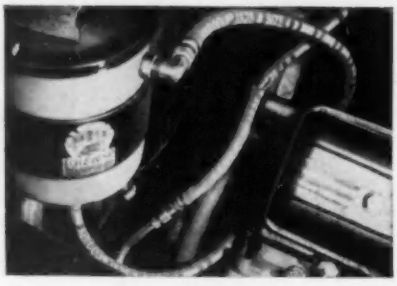
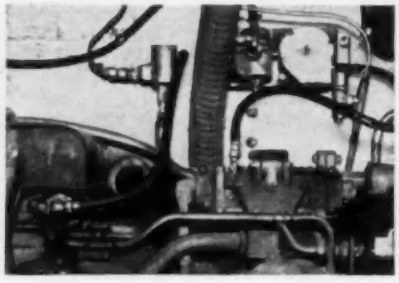
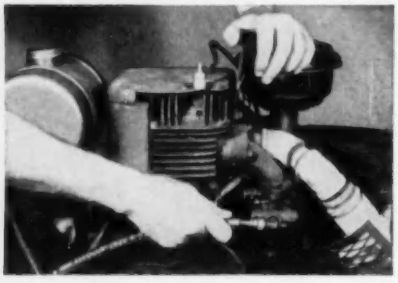


Aeroquip Socketless fittings and hose were used to make oil filter and fuel lines on this automobile engine.



Socketless fittings and hose were used to make the air unloader line to the O-1 governor on this G.M. coach.



This power mower fuel line points up the ability of Socketless fittings and hose to withstand vibration.

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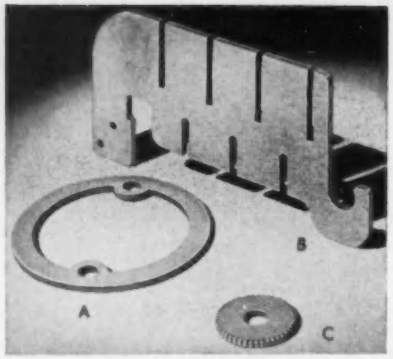
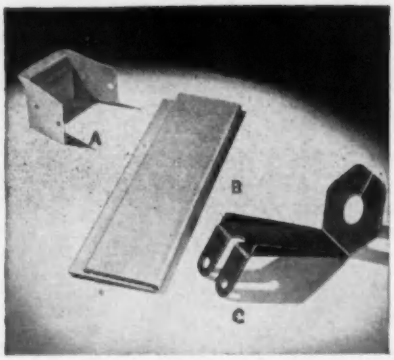
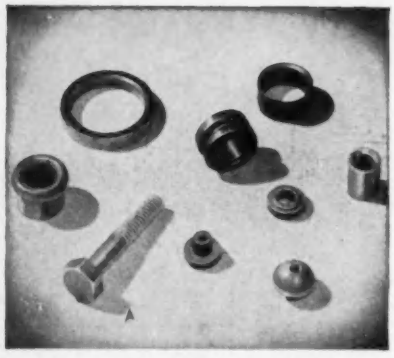


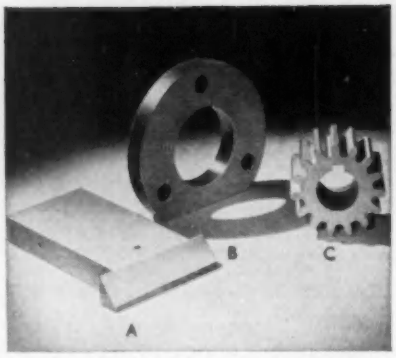
A. Sheet stock, shear strips, punch. B. Sheet stock, shear, punch blank, gang saw notches. C. Sheet stock, shear strips, punch blank, mill notches.



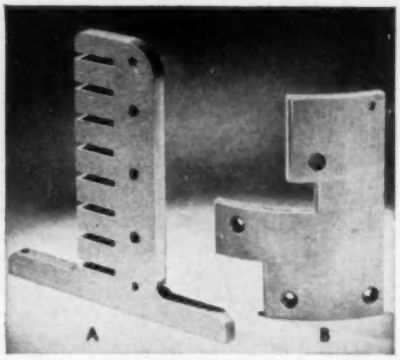
A. Sheet stock, shear strips, punch, form. B. Sheet stock, shear to size, drill, form. C. Sheet stock, shear strips, punch pieces, form in mold twice, rubber stamp twice.



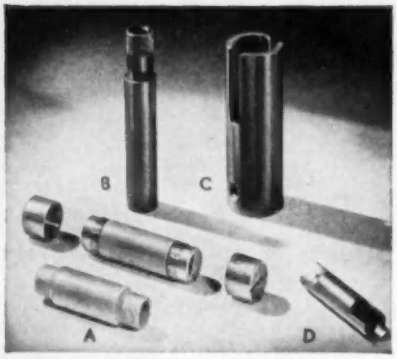
A. Rod (hexagonal), smooth saw, automatic screw machine, turn shoulder thread, champfer and cut off. Remainder are automatic screw machine parts made from Diamond Fibre by C-D-F.



A. Sheet stock, sand, smooth saw to size, smooth saw bevel, smooth saw corner cut out, drill. B. Sheet stock, hand saw, turn OD, bore ID, smooth saw side, drill five blind holes with jig. C. Sheet stock, sand, hand saw, rough bore ID, hob teeth, finish bore ID, machine keyway.



A. Sheet stock, sand, smooth saw, drill, smooth saw to shape, radius three corners, gang saw nothches. B. Sheet stock, band saw rough blanks, form, smooth saw width, length and shape, radius edges, drill with jig, countersink.



A. Tube, automatic screw machine, turn shoulders, champfer and thread end, thread other. B. Tube (long pieces), smooth saw, tap threads, screw machine, (small pieces) auto. screw machine, thread, knurl, champfer, cut off. C. Tube, smooth saw to length, punch twice, countersink. D. Tube, automatic screw machine, champfer, cut off, punch.

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Vulcanized Fibre is a wonderful material if you know where to use it and how to buy it. We suggest on many jobs that it's best to do the fabrication and forming in C-D-F's shops. Why? Because C-D-F knows how. Since 1895 the company has put fibre to work in everything from buggy axle bushings to metal clad radio parts. The handling of thousands of set-ups for high speed, low cost production runs gives C-D-F an "experience bank" to draw from. Shop supervisors have a wealth of short cuts, little tricks that result in lower prices for you. They know the material and its peculiarities.

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How long has it been since you examined the unique properties and wide range of C-D-F fibre grades? Vulcanized Fibre is arc resistant, mechanically strong, non-corroding, half the weight of aluminum. Repeated moistening and drying in forming insignificantly alters the nature, structure or quality of the fibre.

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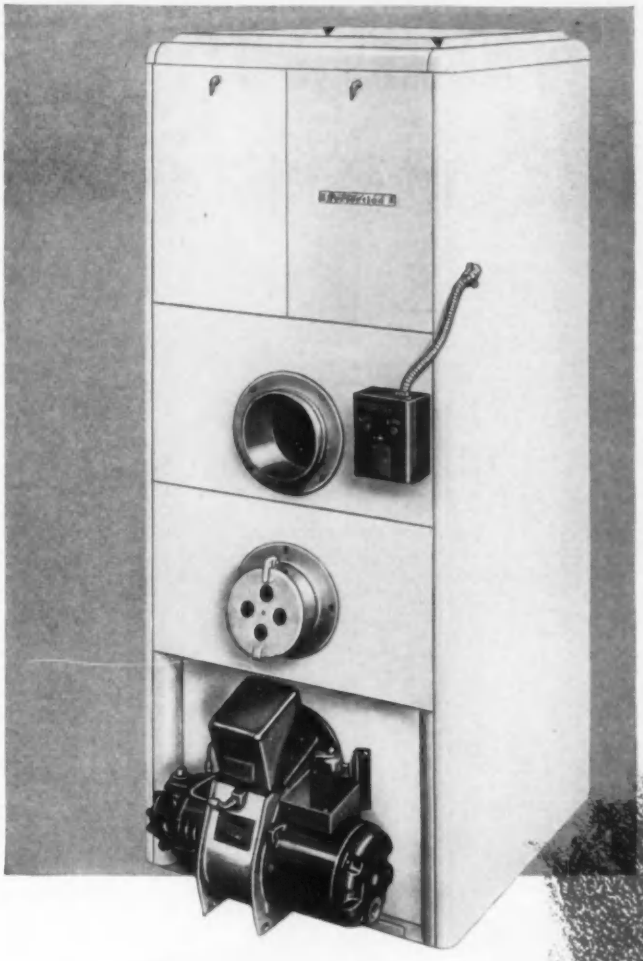
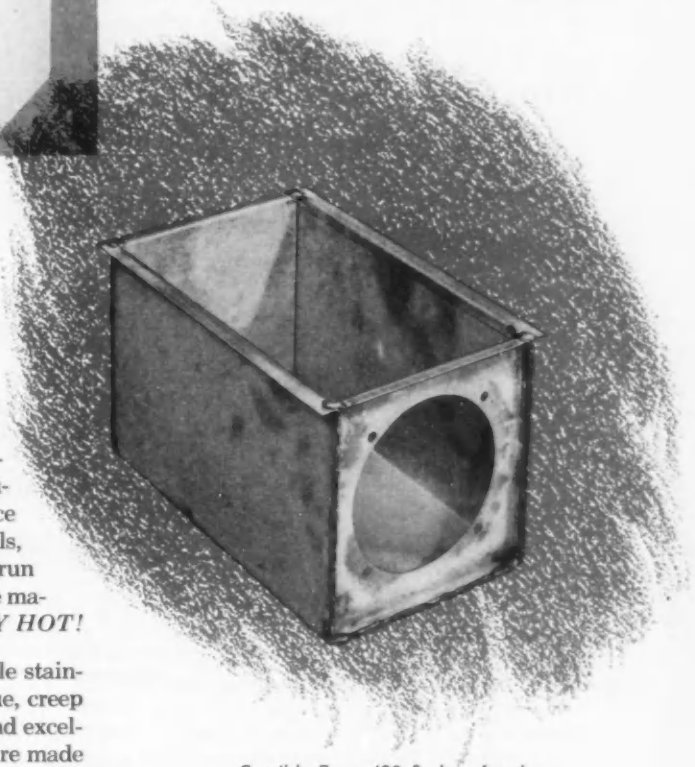


If it's meant to get

HOT

...use

CRUCIBLE STAINLESS



Crucible Type 430 firebox for the Perfection OC 90V Oil-Fired Furnace.

Say *"stainless steel,"* and most everyone thinks of bright appearance . . . corrosion resistance . . . strength without excess weight. But these properties are actually secondary in some applications.

As an example, take stainless steel's remarkable resistance to heat. That's the reason why The Perfection Stove Company uses types 309 and 430 Crucible stainless steels for its gas- and oil-fired furnace components — fireboxes, throat and burner bowls, combustion chambers, and baffles. In the long run stainless is the most dependable and least expensive material they can use for these parts that get *REALLY HOT!*

Of course, in addition to heat resistance, Crucible stainless steels offer corrosion resistance . . . high fatigue, creep and structural strength . . . resistance to wear . . . and excellent workability. And at Crucible, stainless steels are made by specialists who are concerned only with special purpose steels. They welcome the opportunity to help you select the best grade for the job. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

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A compact powerhouse of hydraulic action. The **400** is the smallest in outside dimensions (4½" square) of any pump with equal capacity.

MATERIAL:	Die Cast Aluminum Body Hardened Steel Precision Gears
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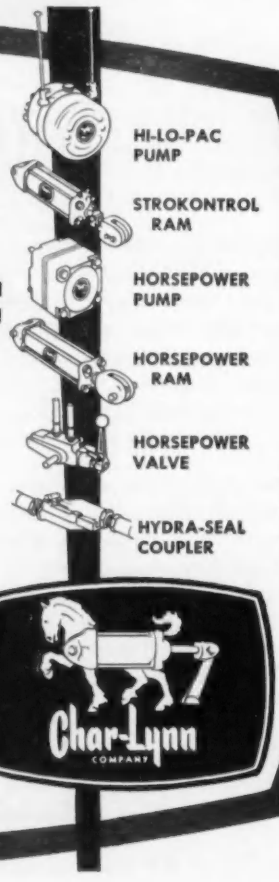
MAXIMUM SPEED:	2400 rpm
DELIVERY:	10 gpm at 1750 rpm
SHAFT:	⅞" diameter 3/16" woodruff key
MOUNTING:	Directly on studs. Can be reversed for mounting off back of pump.
OIL PORTS:	¾" NPT tapped
SHIPPING WT.:	11 pounds



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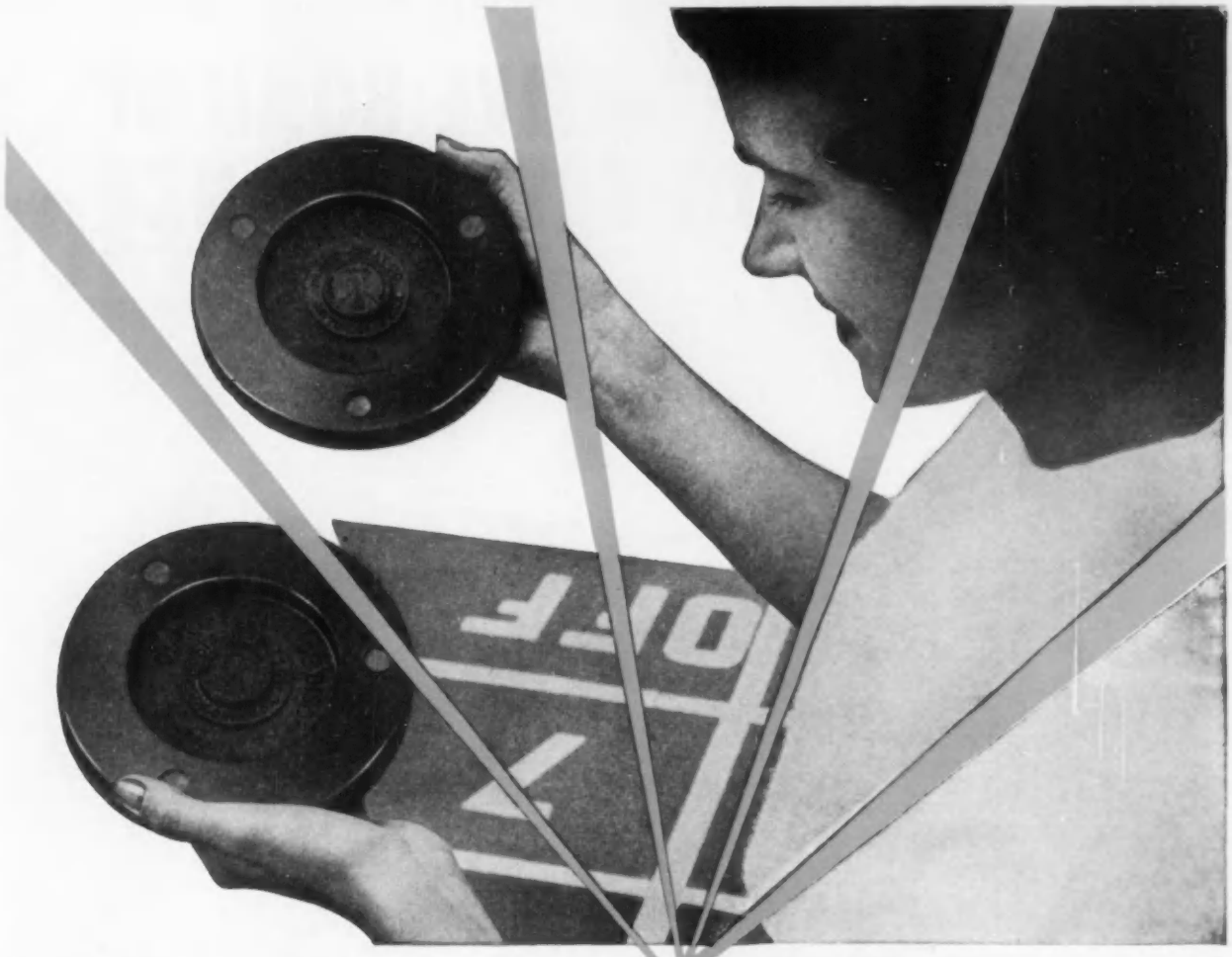

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Shuffleboard discs must glide smoothly, withstand abrasion and take numerous impacts without chipping. They must also meet precision dimensions and weight tolerances and have the right degree of resilience for proper rebounding during play.

If you had to meet these specifications, you'd look for a material that was tough, molded to a smooth finish and—since the demand was great—insist that it fit the requirements of high speed, mass production methods. Chances are you'd do exactly what Dimco-Gray Company, Dayton, Ohio, did. This leading manufacturer of shuffleboard equipment, after researching various materials, selected Rogers RX-425, a medium-impact phenolic.

And here are the reasons why: RX-425 is tough, yet resilient. It molds to an excellent finish. It withstands repeated shocks. Just as important as the handsomeness of the end product is RX-425's production assets. It can be automatically preformed into hard, volume and weight-controlled pills and either transfer or plunger molded. In fact, it is almost as easy to mold as general purpose phenolics. It's available in colors, too.

When you next need a part that has to be tough and yet easy to produce, specify Rogers RX impact phenolics. You'll get the quality you need at an amazingly low unit cost.

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ROGERS, CONNECTICUT

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DUROIDS — for Gaskets, Filters, Electronic Devices, etc.
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PLASTICS — Special Purpose Molding Compounds and Laminates

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LORD CONTROLS VIBRATION...ANYWHERE!

THE MOST POSITIVE BOND OF PRODUCT TO PERFORMANCE

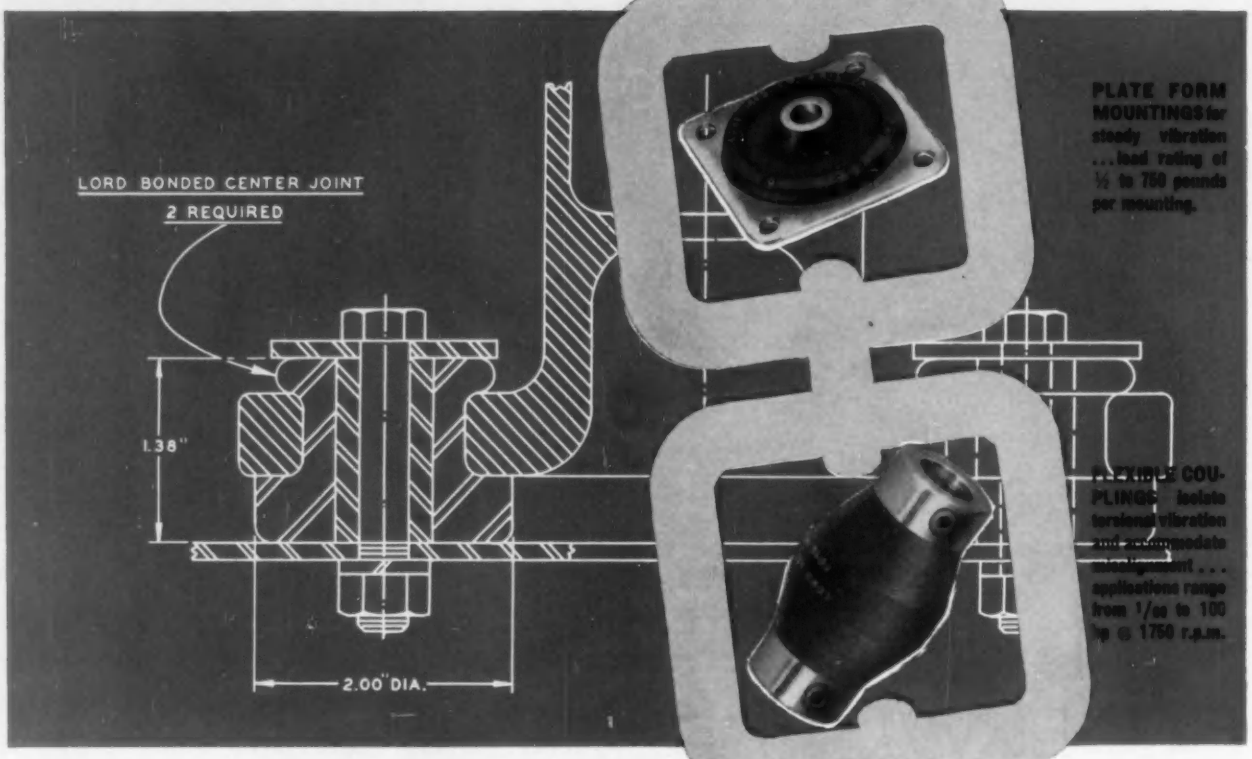

PLATE FORM MOUNTINGS for steady vibration ...load rating of ½ to 750 pounds per mounting.

FLEXIBLE COUPLINGS isolate torsional vibration ...accommodate misalignment ... applications range from 1/20 to 100 hp @ 1750 r.p.m.

CHAN-L-MOUNTS provide excellent reduction of steady vibrations and occasional shock problems. Designed to provide maximum deflection for their size.

Vibration control is a vital element of improved product performance . . . and the most positive way to control vibration is through LORD Bonded-Rubber Mountings. Here are several outstanding reasons why:

Isolate Vibration — Stop noise transmission or vibration caused by moving mechanical components.

Lengthen Product Life — minimize stresses caused by shaft misalignment or torsional vibration.

Reduce Maintenance Expense — the rubber element absorbs flexing action . . . no surfaces to wear or chafe . . . no lubrication is needed.

LORD maintains a staff of vibration engineers to assist manufacturers in isolating destructive vibration. They will gladly assist you by designing and producing the most economical and efficient mounting for your needs. Call or write the LORD Mfg. Co., Erie, Pa.

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DESIGNERS AND PRODUCERS OF BONDED RUBBER PRODUCTS SINCE 1924

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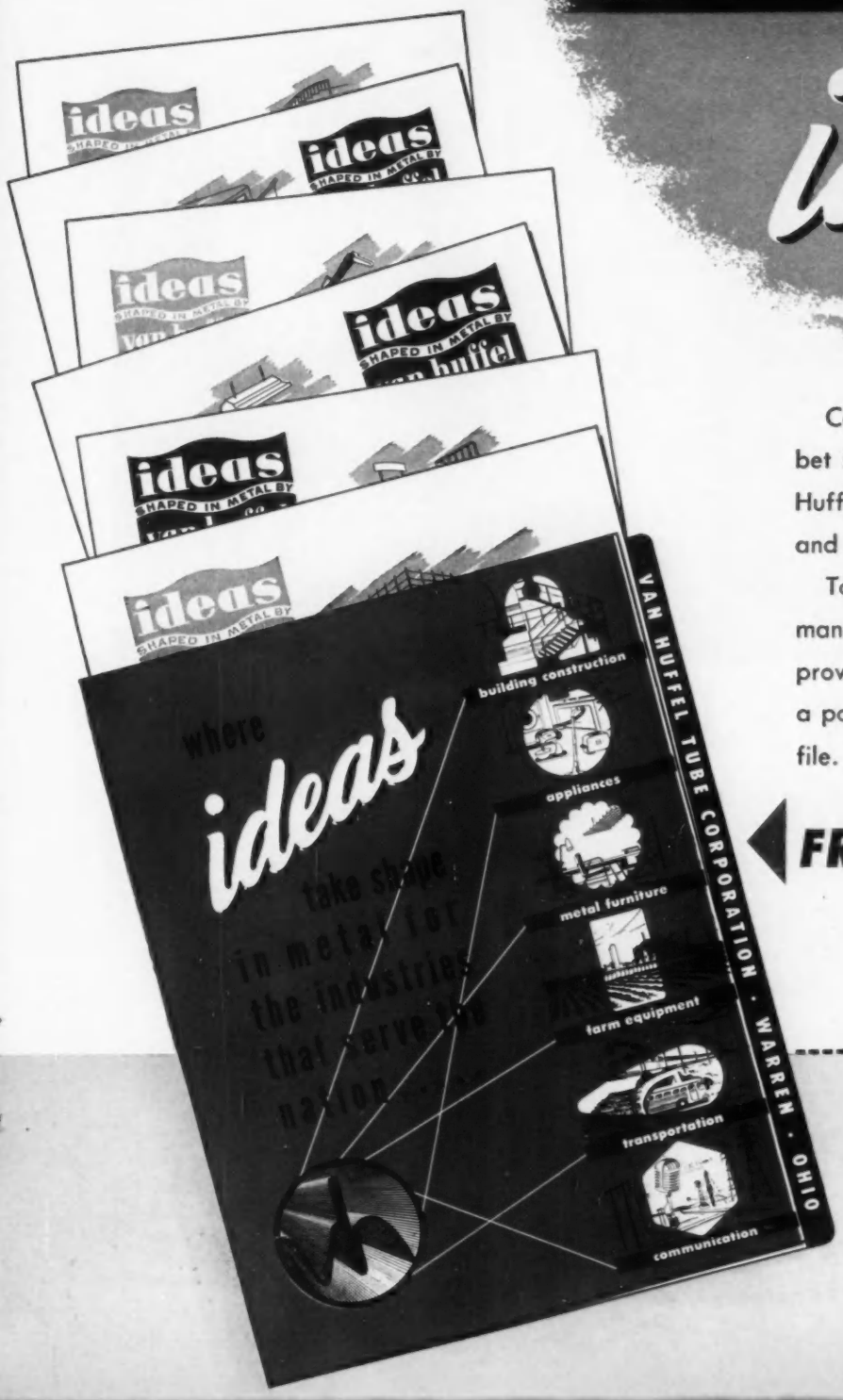
material handling equipment

ideas?



Could be you are overlooking a good bet if you aren't familiar with what Van Huffel can do in cold forming metal shapes and tubing.

To give you a better picture of how other manufacturers are cutting costs and improving their products, we have prepared a portfolio of ideas that should be in your file. It's yours free for the asking.

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Please send me the MATERIAL HANDLING EQUIPMENT idea portfolio MH-32

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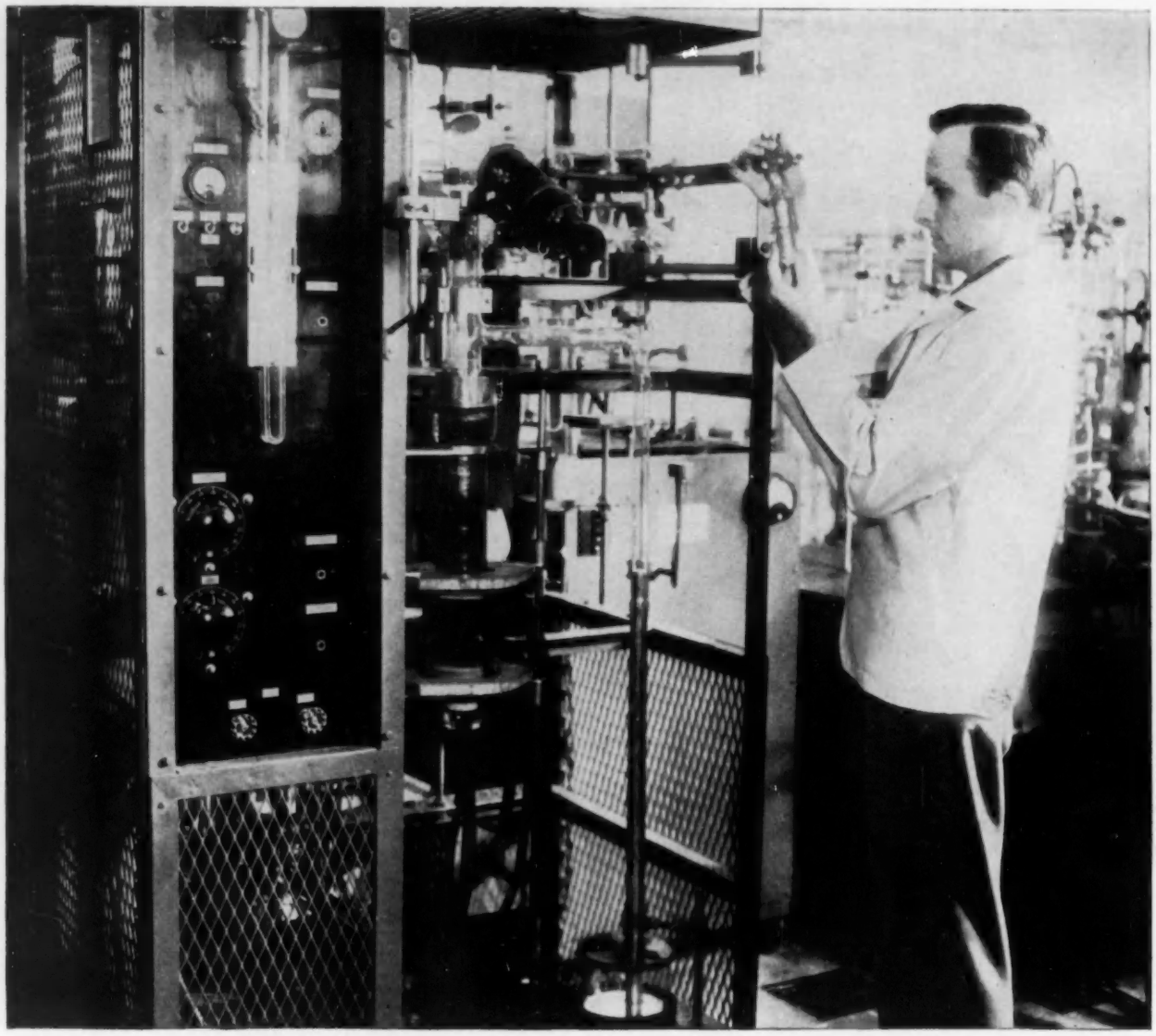
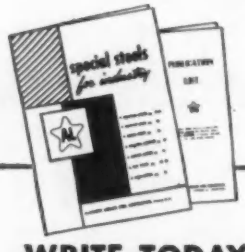


They search so that you may find



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The technician above, in the last-word Research Laboratory recently built near our Brackenridge, Pa., plant, is running an involved analytical test on apparatus of our own devising—developed because we wanted more accurate answers on special alloy steel problems than we could get in any other way. In all of the A-L plant laboratories, the hunt for alloy steels of improved properties and greater value is always at full speed, so that *you* can have the materials you need to cut your costs or improve the competitive position of your products. ● Whenever you're trying to take a step ahead in resisting corrosion, heat, wear or great stress, or in securing special electrical characteristics, call on us. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

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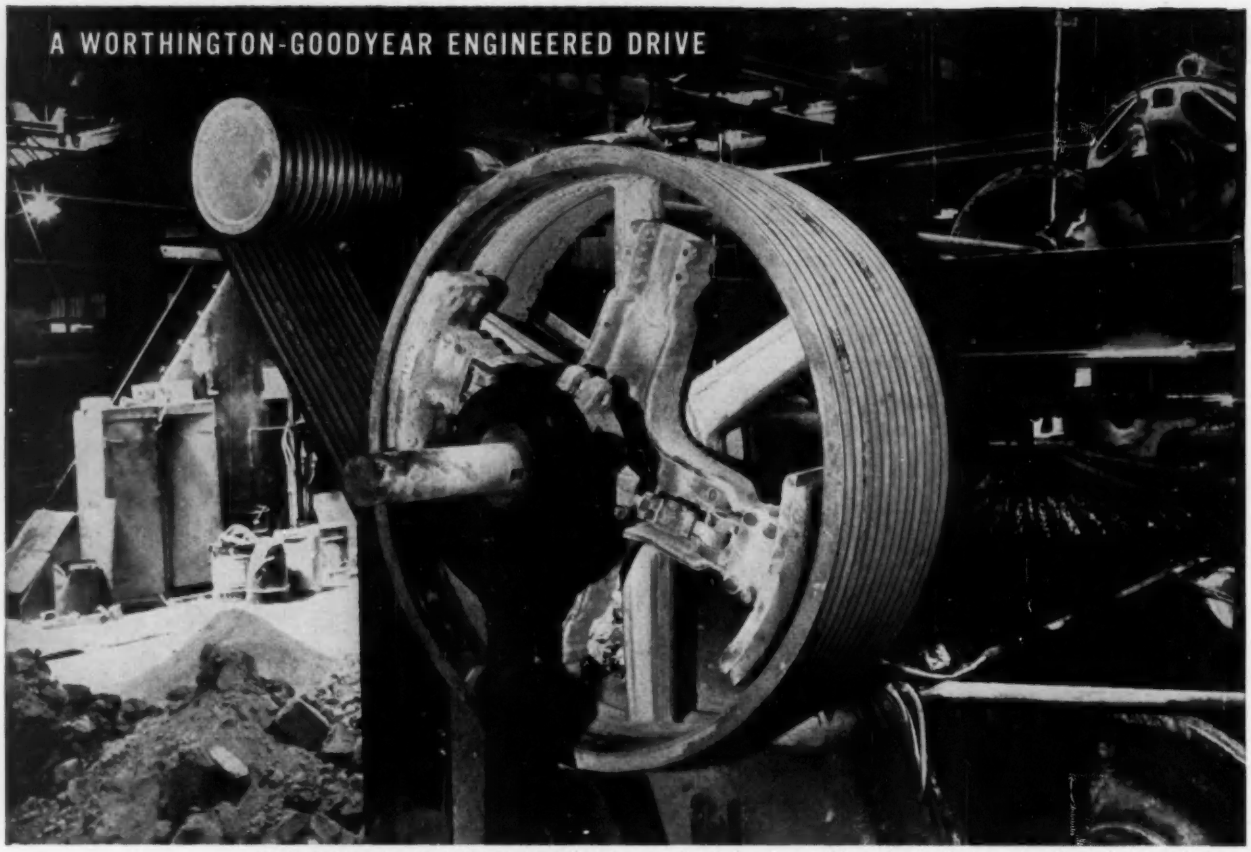
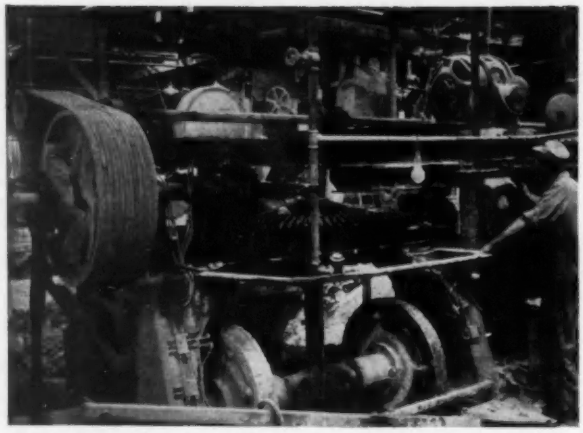


WORTHINGTON MULTI-V-DRIVE takes heavy shock loads on this wet-pan that crushes huge lumps of clay.

Belts hold as machine crushes 120-lb lumps



SMOOTH, NON-SLIP DRIVE for this wet-pan is provided by Worthington QD sheaves and Goodyear V-belts.

Worthington Multi-V-Drive solves critical drive problem

Driving a machine that crushes, mixes and tempers crude clay is a real workout for any mechanical power transmission setup—especially with lumps weighing as much as 120 pounds.

After two years of this heavy-duty operation, not one belt has been replaced on this wet-pan. And there's no noise, slippage of belts on sheaves, and no resulting power loss. Because of this fine record, Worthington Multi-V-Drives, with QD* sheaves and Worthington-Goodyear V-belts, will be installed on other wet-pan pulverizers.

Find out how this Worthington-Goodyear drive team can pay off for you, too. Write us. Worthington Corporation, Section MV.4.5, Oil City, Pa. *Reg.U.S.Pat.Off.

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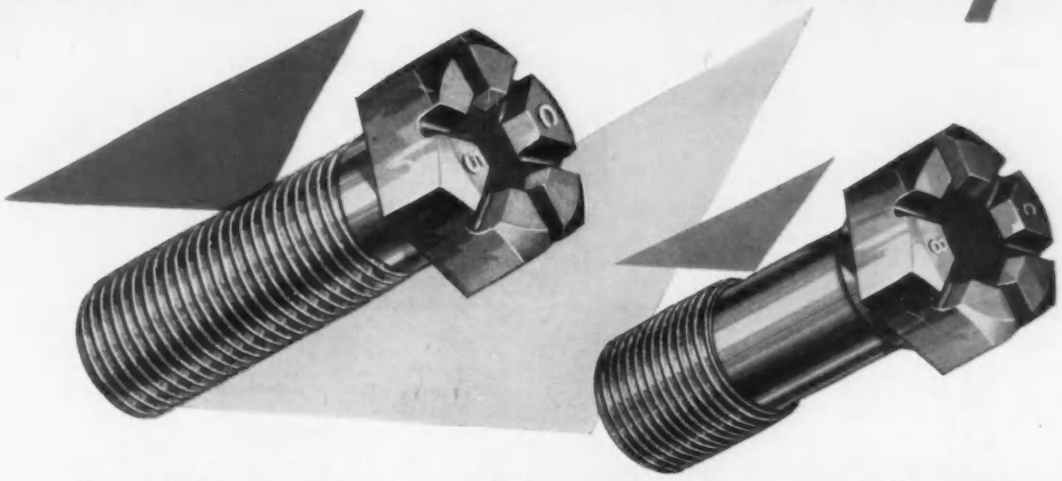
Compressors • Pumps • Multi-V-Drives • Variable Speed Drives

Which is the CleCap?



...both are—all types and sizes of the vibration-proof Place Bolt

Place Bolts are used in all types of automotive and farm equipment, for example—in fly wheels, main bearings, connecting rods and other high vibration points.

Be sure you don't overlook the definite advantages of this *one-piece self-locking* fastener where you have a vibration problem—the *tough strength* developed by cold-forging, and the *economy of assembly* (elimination of locking devices and no limit to the number of times the Place Bolt may be re-used). Saves weight, saves space, saves time.

Licensed under U. S. Patent No. 2543705, CLEVELAND has facilities for mass production of sizes ranging from ¼″ to 1¼″ diameter, standard or special shanks, in carbon (C-5) or alloy (C-8) steel.

Write for guide chart for calculating wrench torques for "Place" type bolts.

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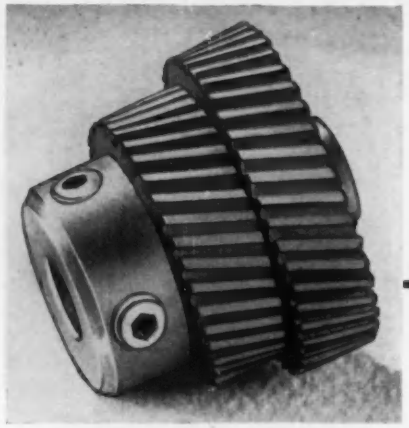
Structural Bolts to ASTM Specification A325
Tractor Bolts
Special Hot and Cold Headed Parts

Facilities to make larger diameters than listed

Originators of the Kaufman DOUBLE EXTRUSION Process



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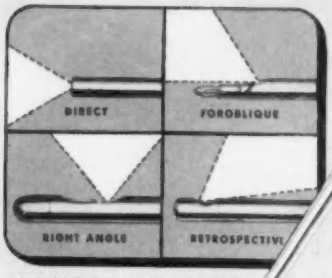

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Low-Cost, Explosion-Proof SKINNER Solenoid Valve Underwriter Approved for Gas Vapors, Carbon and Grain Dust Applications

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V10 Series
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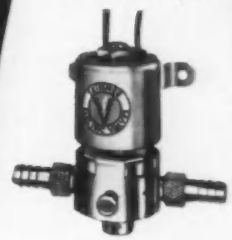

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V4 Series
2-Way
0-20 p.s.i.

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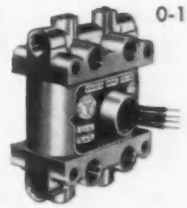

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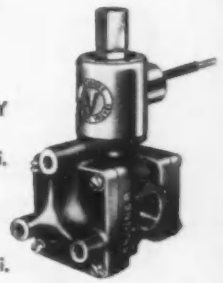
V9 Series
4-Way 0-150 p.s.i.



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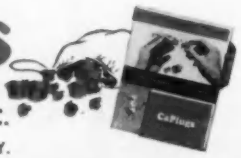

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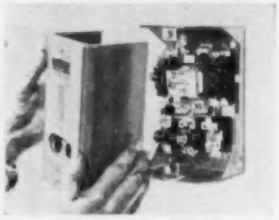
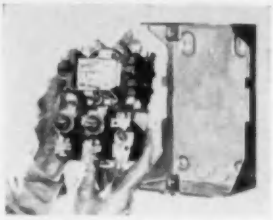
Cutler-Hammer ★ ★ ★ Motor Control



3-D Accessibility
Removing wrap-around cover bares starter for three-directional accessibility. Wide open at front and sides. See everything, reach anything. Wiring is simplified, routine inspection easy.



Unit Panel Construction
Starter mechanism is removed from case by simply loosening three screws. Mounting case, connecting conduit and pulling wires is a cinch. A great time saver.

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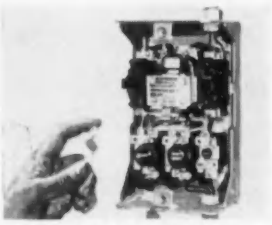
Only *three* overload relays can provide positive three-phase protection to stop needless motor burn-outs and interruptions. Only C-H offers three overload relays in standard starters.



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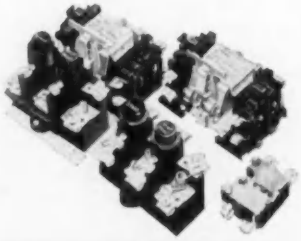
Only C-H offers adjustable load sensing coils . . . for 3% loading accuracy instead of the 10% to 12% in all other controls. Permit motors to work harder without damage.

It is here . . . Cutler-Hammer ★ ★ ★ Motor Control for your larger motors, NEMA Size 2 Starters with the famous three stars on the Cutler-Hammer nameplate. The three stars that stand for three entirely new standards in motor control performance and value. Star #1: Installs easier. So much easier that installation savings often exceed the cost of the control. Star #2: Works better. So much better that this control often pays for itself many times over in just the production interruptions it avoids. Star #3: Lasts longer. So much longer that this control *never* needs maintenance care or expense in 90% of its uses. If you are one of the many users who have proved these are facts, not mere claims, you will welcome the news that your larger motors can now have this same control. Order Bulletin 9586, Size 2, today from your nearby Cutler-Hammer Authorized Distributor. He is stocked and ready to serve you. CUTLER-HAMMER, Inc., 1332 St. Paul Ave., Milwaukee 1, Wisconsin.

Control Panel Designers

New Control Components
All parts of the new C-H ★ ★ ★ Starters in NEMA 0, 1, and 2 Sizes are available as components; also complete starters on convenient unit panels. Electrical interlocks are available to provide additional control circuits when desired.



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CUTLER-HAMMER ★ ★ ★ MOTOR CONTROL C-H

Integral Gear Teeth vs. Ring Gear Insert

As Manufactured by
The Steel Products Engineering Co.
Springfield, Ohio

The ability of a Fellows Gear Shaper to cut teeth-against-shoulder gears with complete precision control permitted more economical and weight-saving, one-piece design!

Thanks to the Fellows Method . . . you have more freedom in the design of gears and other parts that will improve the performance of your products.

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Take Advantage of This Unusual Combination of Properties

Strength	Excellent Machinability
Toughness and Ductility	High Impact Resistance
Rust and Corrosion Resistance	Versatile Castability

• Malleable iron is a cast ferrous alloy heat-treated to provide a remarkable combination of properties. Malleable castings are both strong and tough—flow under excessive compressive and transverse loads, seldom fracture.

• Malleable castings machine easier than any other ferrous material of comparable strength and toughness.

• Malleable iron can be cast into intricate shapes close to final form, greatly reducing machining costs and eliminating complicated and costly assemblies.

• Malleable castings are highly resistant to atmospheric corrosion and are widely used for products used outdoors.

• Modern foundry methods and careful scientific casting control assure you of uniformly high quality castings for better products.

For complete specifications and tolerances for both standard and pearlitic malleable castings, write to the Malleable Founders' Society.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

BARBER COLMAN d-c motors

compact, powerful high quality for a wide range of applications

Looking for a d-c fractional hp motor of unusually high quality, high dependability? Specify Barber-Colman, the *versatile* line of small motors in both permanent magnet and split series types . . . in various mountings and speeds, and outputs up to 1/10 hp. Ideally suited to power electro-mechanical actuators, generators, switches, blowers and programing devices. Barber-Colman small d-c motors are also available with lightweight radio noise filters to meet radio interference requirements of USAF. They are ideally suited for use as tachometer generators. Whatever your problem involving small motors, consult Barber-Colman Company for an expert solution.

Write for free catalog F. 4344-i

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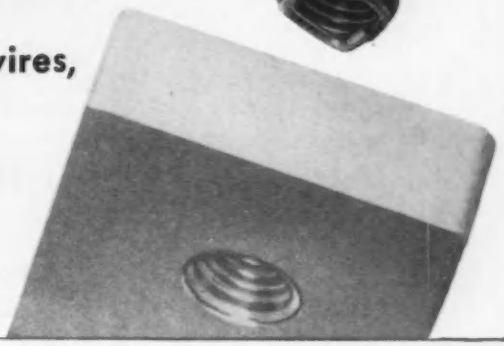
Dept. N, 1412 Rock Street, Rockford, Illinois

"Biggest Advance In Threaded Assemblies Since World War II"

NEW INVENTION affects every designer



Obsoletes lock nuts, lock-washers, lock wires, stop nuts in thousands of applications

Here is a locking device that becomes an integral part of the tapped hole! It's the new Screw-Lock Insert made only by Heli-Coil Corporation of Danbury, Conn.

How it works. Wound into the tapped hole during production, the ***Heli-Coil**** Screw-Lock Stainless Steel Insert becomes the permanent female thread. *Standard* cap screws and studs spin into it easily until the final turn when they are gripped tight by the bottom thread. This grip provides the same torque as required by AN-N-5b specification for lock nuts. The part can always be disassembled simply by application of the same off as on torque and can be replaced and removed again and again without loss of torque.

Better temperature characteristics. Because the gripping element is stainless steel, and because it is located at the bottom of the hole, the Screw-Lock Insert permanently holds its grip at temperatures beyond the range of other devices.

No design or production change. Because Screw-Lock Inserts provide all the improved-thread features of regular ***Heli-Coil*** Inserts, including much higher thread strength and better stress distribution in surrounding metal, you can safely use this amazing new type lock fastener without enlarging bosses or flanges. They can easily be included in a part now in production.

LOOK WHAT YOU CAN DO!

Eliminate costly, cumbersome locking devices • Cut weight • Cut bulk • Cut assembly cost • Cut fastener cost • Cut vibration loss, fatigue • Provide faster disassembly • Provide higher thread strength • Provide automatic protection against stripping, corrosion, seizing *Without Changing "Frozen" Designs!*

Investigate TODAY additional advantages ***Heli-Coil*** Screw-Lock Inserts may have for you.

Consult *your* local ***Heli-Coil*** Applications Engineer. You'll find him listed in the Yellow Pages of your phone directory under INSERTS – SCREW THREAD. Or write or wire direct for complete design data, no charge, of course.

* Reg. U. S. Pat. Off.

No Locking Needed?
Use Standard *Heli-Coil* Inserts

Used for years throughout the aircraft, automotive, and other industries, ***Heli-Coil*** Screw Thread Inserts are precision-formed coils of stainless steel wire that form vastly superior permanent female threads in tapped holes—smoother, corrosion-proof, strip-proof—so much stronger that even in soft metals excessive torque will shear off the bolt before the female threads will strip. You can convert these advantages into smaller, fewer fastenings—less bulky design, lighter weight, lower production costs—*in short, a competitive edge for your product.*

HELI-COIL **SCREW-LOCK INSERTS**

Products of Heli-Coil Corporation,
DANBURY, CONN.

HELI-COIL CORPORATION
142 SHELTER ROCK LANE, DANBURY, CONN.

- ☐ **NEW — Design manual available on *Heli-Coil* Screw Thread Inserts.**
- ☐ **RUSH complete design data Handbook on *Heli-Coil* Screw-Lock Inserts.**
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☐ *Heli-Coil Corporation has the world's best staff of Thread Engineers. If your company would be interested in a "Thread Problem Symposium" CHECK HERE.*

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Just check above and attach to your letterhead.

See Our Catalog in SWEETS

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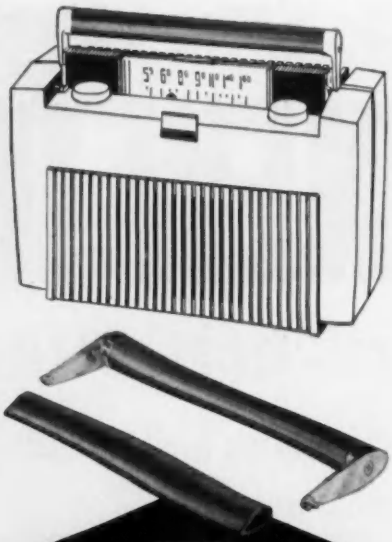

WHY ANCHOR PLASTIC EXTRUSIONS ARE USED FOR RADIO HANDLES

Radio Designers were searching for sturdy, lightweight, colorful handles to be used on high-quality, 2-way portable radios. They chose Anchor extruded acrylic tubes with an egg-shaped cross-section because of their ability to meet exacting requirements for close tolerances and glossy finish. Colors selected were green, fawn, and ivory.

Perhaps an Anchor extrusion can solve a similar design problem for you. Why not write for our new brochure giving applications of thermoplastic extrusions and details on materials.

ANCHOR PLASTICS CO., INC.
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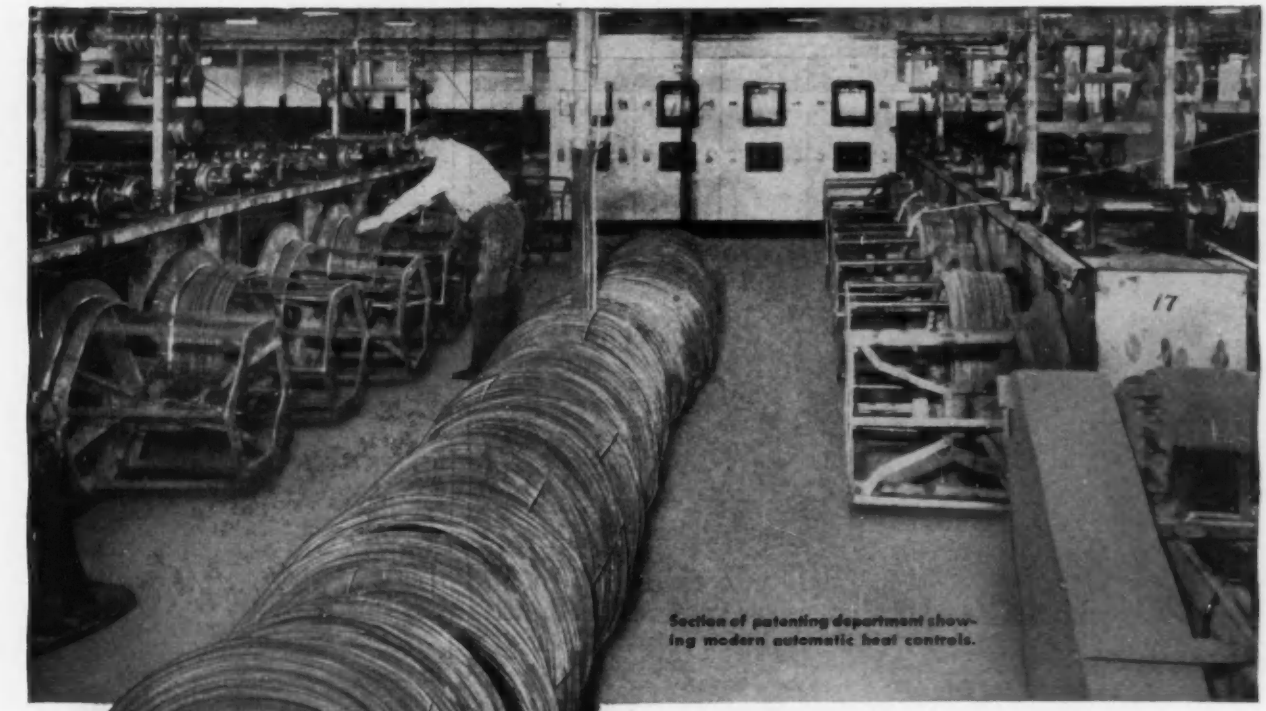

Section of patenting department showing modern automatic heat controls.

wire control

to save you money!

• The accuracy with which your wire specifications are met, *and held,* quite naturally has an important bearing on the cost, speed and quality of your production. That's why you can profit by National-Standard's facilities and exceptional experience in producing fine wire of many metals and alloys for exacting needs.

Here, all phases of wire processing . . . drawing, cleaning, heat treating, plating, finishing . . . are controlled to a degree and accuracy never exceeded, not often equalled. It's a firmly rooted National-Standard policy that can save you time and money.

Remember, too, another National-Standard policy that can work to your advantage—highly qualified engineering service in the development and application of special wire to solve special problems. As always, it's yours for the asking.

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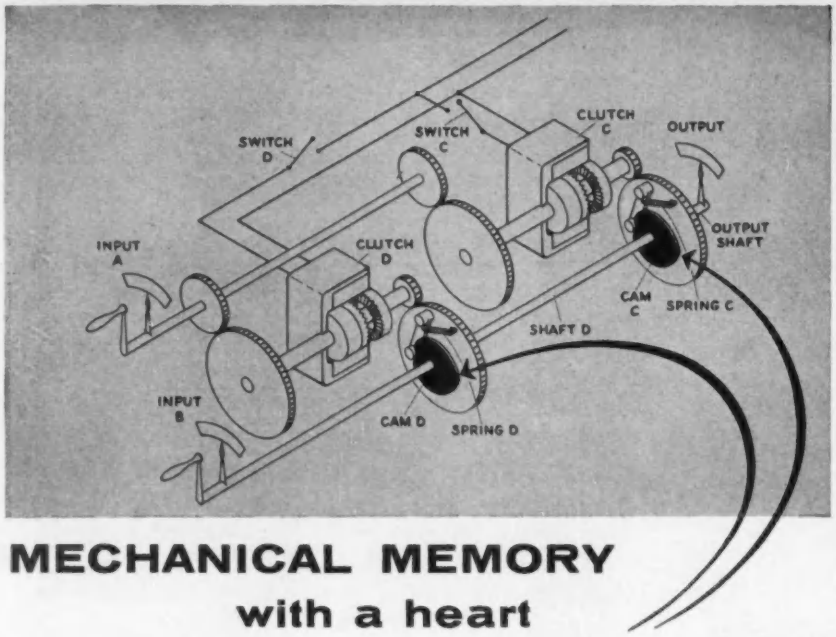
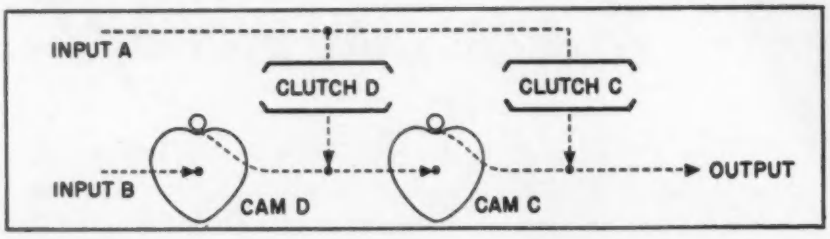


MECHANICAL MEMORY
with a heart

Ford Instrument Company engineers draw on the entire scope of scientific knowledge to solve each problem. In a recent project, Ford found good use for components it developed a score of years ago to produce a mechanical memory system whose accuracy is independent of the time interval, and which meets a military requirement of absolute reliability.



In an instrument in which the input quantities may vary with time, it is desired to produce an output equal to the change in one quantity A since the time t_1, added to the value that a second quantity B had at time t_1. At the same time it is desired to store another output equal to the change in quantity A since a second time t_2, added to the value that the quantity B had at that time t_2. It is further desired at any subsequent time to be able to read the first output or alternately the second output.

The storing of this information is accomplished by closing clutch C at instant 1 and clutch D at instant 2. The first output is then read directly at any subsequent time and the alternate output by opening clutch C. To recycle – clutch D is then opened.

Whatever problems must be solved in designing and manufacturing computers and controls, skills in electronics, magnetics, hydraulics and mechanical and electrical techniques are called upon by Ford engineers to develop the best instruments for the purpose.

If you have a problem in control engineering, Ford Instrument Company's forty years of experience in high precision design and production will help you find the answer.

46

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
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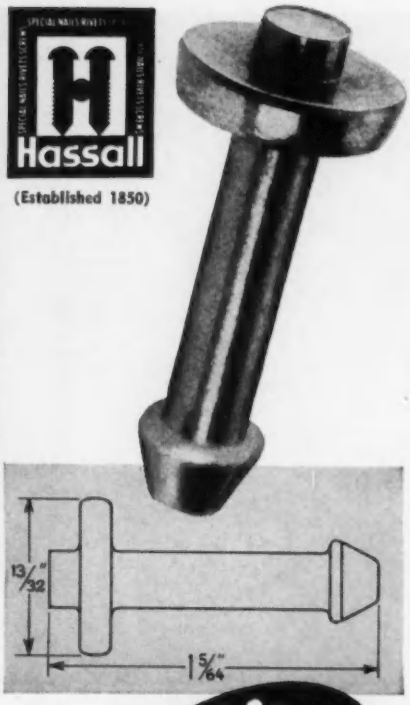
Hassall
(Established 1850)



This cost:

SCREW MACHINE	$14.00 per thousand
COLD HEADED	$5.20 per thousand
SAVING	$8.80 per thousand

How about your fasteners or small parts? Have you had an estimate from HASSALL?

This is a typical example of how HASSALL saves thousands of dollars for cost-conscious manufacturers in hundreds of industries. This part is made in one piece by cold heading . . . the part is not only lower in cost but also stronger and just as accurate. Savings amount to $8.80 per thousand and this manufacturer used hundreds of thousands a year!

Perhaps your parts can be made by this better, lower cost method. Send samples or sketches of your parts for a prompt, $ $ $ saving quotation.

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- Send for 3 color decimal equivalent wall chart.
- On request, our 36-page catalog.

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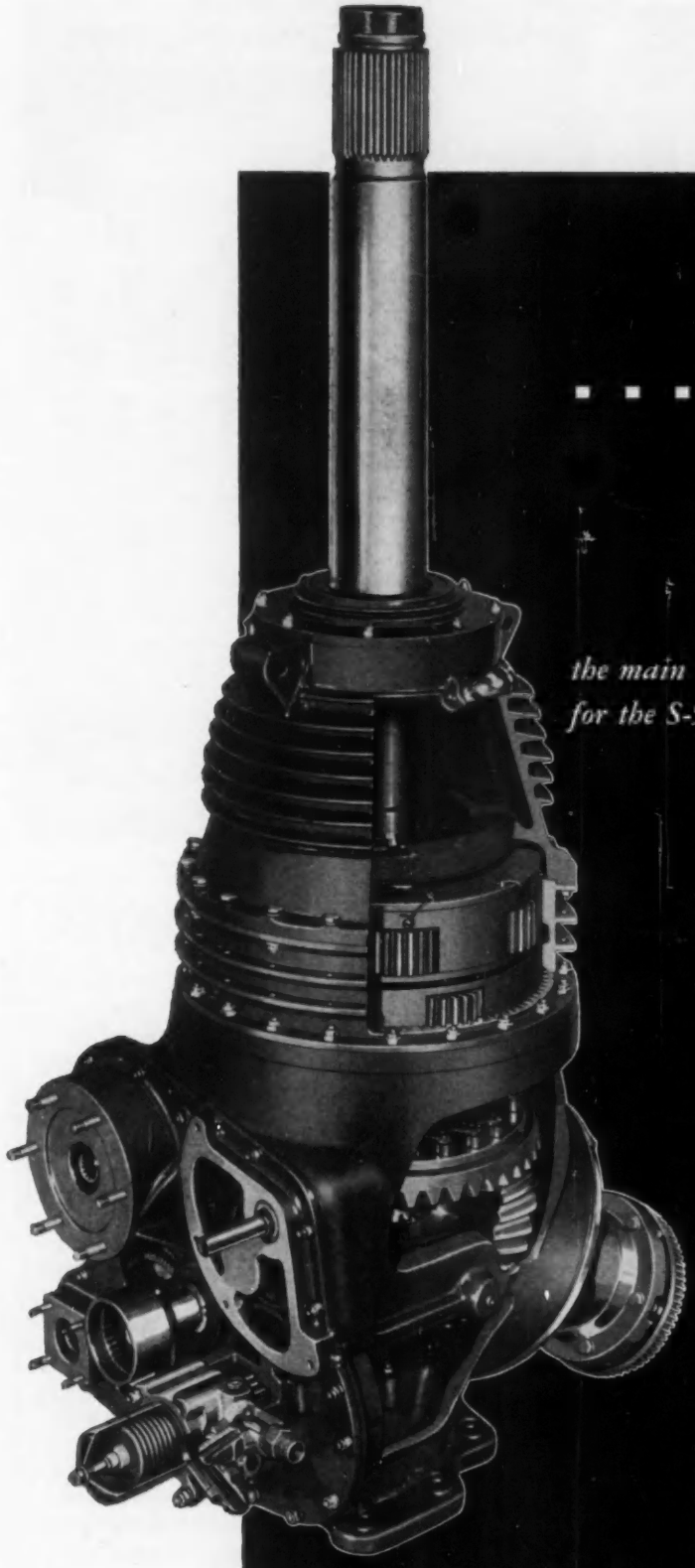
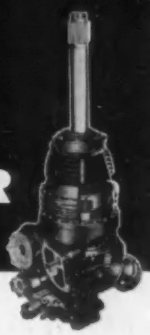


. . . and then we built

the main rotor transmission for the S-55 Sikorsky Helicopter.

High on the list of "things we are proud of" at IGW is the transmission shown here (demonstration cut-a-way). Precision built to transmit 700 H. P. with an input speed of 2400 RPM and a reduction ratio of 11.348 to 1. In spite of high stresses and great complexity the service life of this transmission has been outstanding.



INDIANA GEAR

INDIANA GEAR WORKS, INC. • INDIANAPOLIS, INDIANA

Arwood investment casting saves up to 75%... even on complicated shapes

The Arwood investment casting process permits great design freedom. Many former sub-assembly jobs are now being designed as single-unit castings, with complicated parts being cast in unmachinable alloys. Applications are virtually unlimited.

Our engineers will be pleased to go over your parts problems with you and help cut your own costs. Why not submit parts or prints to us for quotations? Consultation is free of obligation, of course.

Write for free literature describing the investment casting process.

CASE STUDY

DESIGNATION: Female Hinge

METAL USED: Stainless Steel (AISI 302)

QUALITY CONTROL: Chemical and physical affidavits furnished. Test Bars submitted. Produced with 100% X-Ray requirements.

PARTS: Designed and cast as single unit. Formerly composed of three units welded together.

ADVANTAGES: Strengthened with re-inforcing ribs in U-Bracket. Weight decreased without decrease in strength. Reaming holes only machining required. Formerly holes countersunk outer sides only, now cast with radii on both inner and outer sides. Greatly reduced cost.

ARWOOD

PRECISION CASTING CORP.

68 WASHINGTON STREET • BROOKLYN 1, N. Y.

PLANTS: Brooklyn, N. Y. • Groton, Conn. • Tilton, N. H. • Los Angeles, Calif.

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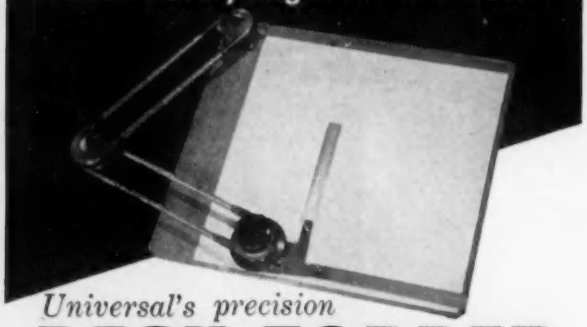

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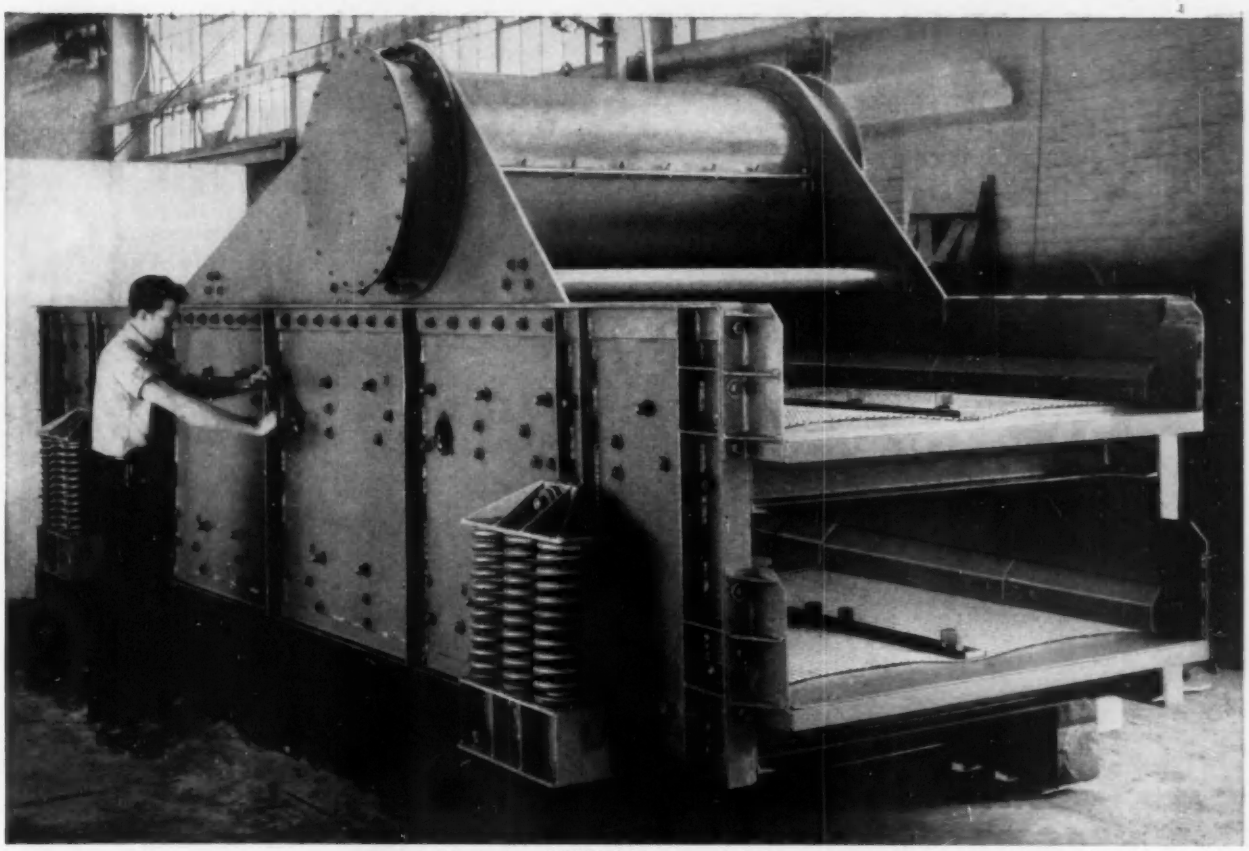


ASSEMBLING an RB&W high-strength bolt on Hewitt-Robins' new Eliptex vibrating machine.

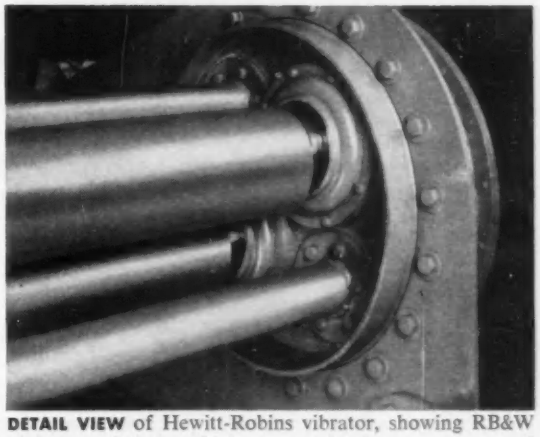
Standardizing on high-strength bolts saves Hewitt-Robins 25%—improves product!

Take a hard look at your fastening operations and you may find you will save a lot by using standard high-strength bolts instead of expensive specials.

Using a standard RB&W high-strength bolt plus a heavy semi-finished nut with two hardened washers, Hewitt-Robins is getting these advantages and savings on vibrating machines: 1. Saving 25% in yearly fastener cost. 2. Eliminating situations requiring body-bound connections with attendant reaming operations. 3. Eliminating all special, finished bolts with varied thread lengths and also all special lock nuts. 4. Eliminating procurement problems and slow delivery of specials. 5. Reducing nut and bolt inventory. 6. Obtaining better performance and lower maintenance on units.

The RB&W product has 2½ to 3 times the clamping force of the previous fasteners. Thus the assembled connection is better able to withstand severe vibration.

Maybe your operation doesn't give fasteners as hard a time as vibrating equipment, but it pays to look into the savings you can expect from specifying standards instead of specials. RB&W has the answers to your questions.



DETAIL VIEW of Hewitt-Robins vibrator, showing RB&W high-strength bolts which must resist shear stress as well as vibration. 4.8

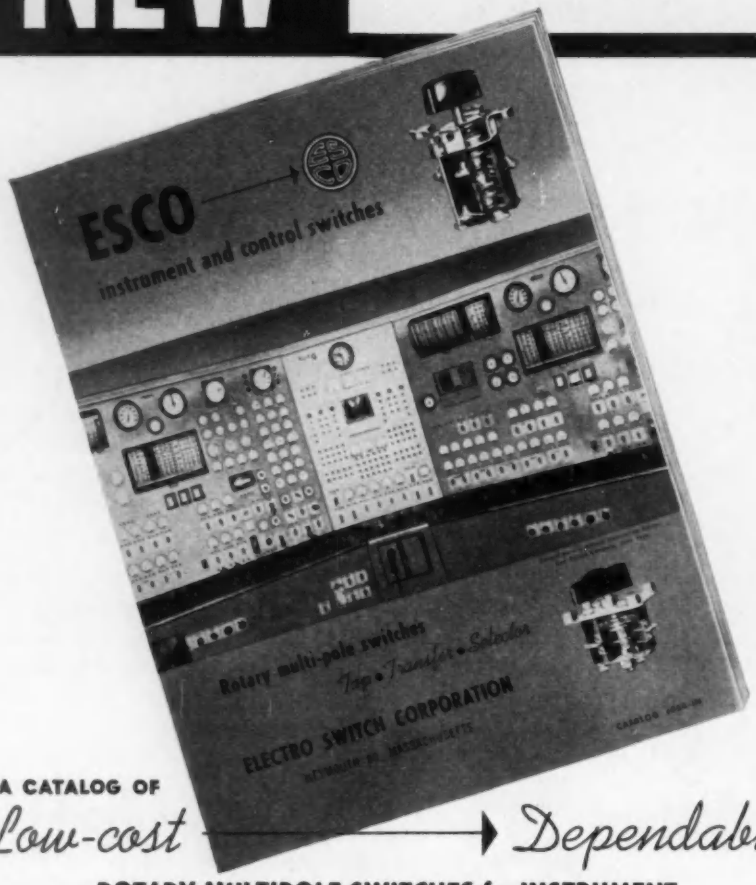
See our insert on high-strength bolts in Sweet's Architectural and Industrial Construction Files.

RB&W **RUSSELL, BURDSALL & WARD**

109 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: PORT CHESTER, N.Y.; CORAOPOLIS, PA.; ROCK FALLS, ILL.; LOS ANGELES, CALIF. *Additional sales offices at:* ARDMORE (PHILA.), PA.; PITTSBURGH; DETROIT; CHICAGO; DALLAS; SAN FRANCISCO. *Sales agents at:* NEW ORLEANS, DENVER, SEATTLE. *Distributors from coast to coast.*

NEW ELECTRO SWITCH CATALOG



A CATALOG OF

Low-cost → *Dependable*

ROTARY MULTIPOLE SWITCHES for INSTRUMENT, TRANSFER, and SELECTOR SERVICE.

ESCO instrument switches permit control of complex circuits with a single compact switch instead of separate switches.

This catalog covers ESCO Type P snap-acting switches, with up to four selector positions, handling 10 amperes at 120 volts a-c, 5 amperes at 240 volts a-c, 3 amperes at 450 volts a-c or 5 amperes at 125 volts d-c, 3 amperes at 250 volts d-c.

The catalog also lists ESCO JR detent-action switches with up to eight selector positions, handling 10 amperes at 125 volts a-c or 5 amperes at 125 volts d-c.

The basic structure of ESCO rotary switches provides for extreme flexibility in design. Tell us your circuit arrangements and the sequences you need, and we will recommend the correct switch for your use.

Write TODAY for your copy of this new catalog.

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For exacting applications specify a Simmonds Access Latch. Precision engineered for high strength and light weight. Capable of handling structural loads, latch is simple, yet positive in action, both opening and closing at a touch. Body tested for ultimate loads up to 3000 pounds. For easy installation (flush) in panels, cargo doors, radomes, etc. Special adjustment features. If your latch problem is exacting, write for design portfolio on the complete line of Simmonds Structural Latches.

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CORNING GLASS BULLETIN

FOR PRODUCT DESIGNERS

Three problems . . . one "E-C" answer

How would *you* shield a complex, static-sensitive hunk of machinery from stray electric charges and still keep its innards open to inspection?

That's a problem IBM faced in designing their now-famous electronic calculator—and solved with E-C glass. Ordinary glass wouldn't do. It wouldn't keep electrons in line. Metal would have been ideal for the shielding job, but not so good for seeing through. E-C coated glass does the one and allows the other.

E-C coated glass is a PYREX brand glass. It stands up well under physical and thermal shocks. But its main claim to fame is the transparent, conductive coating (about 20-millionths inch thin) that's permanently bonded to one side of it. It's this coating that keeps static charges from gumming up IBM's complex circuits busy calculating.

But there's more to E-C coated glass than shunting off unwanted electrical charges. Run a current through it and you've got a heating element that gives forth with a *uniform*, dry, controllable, radiant heat, up to 350° C. The emphasis is on *uniform*—no furrows of heat with coolth in between; no dead spots.

This uniform heating element is already at work in medical sterilizers, drying ovens, room heaters, chicken brooders.

And here's a third kind of application. Turn an E-C panel around and you have a highly efficient heat *reflector*. A well-known steel company protects shear pulpit operators from the fiery heat of billets in process with transparent E-C panels.

Product or process—the potential of E-C coated glass hardly seems tapped. We've learned a lot about it that we'd be glad to share with you.

Multi-aptitude problem—So many folks have exhibited so much interest in the ability of our VYCOR brand 96% silica glasses to survive, unscathed, wide temperature variations (quick switches from below freezing to 1800° F. or higher) that its other attractions for a designer may fall into oblivion.

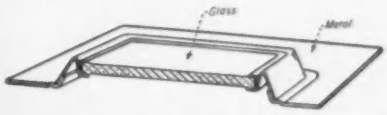
This we don't want to happen, and you might not either. Actually, there are seven VYCOR brand glasses available today—all high silica, but each compounded to develop specific aptitudes. Glass 7911, for example, we control especially for uniform, high transmittance of short-wave ultraviolet. It has notably high electrical resistivity, too, and low power loss. Glass 7910 meets germicidal lamp requirements for transmitting ultraviolet at 254 millimicrons. Glass 7950 will absorb most of the visible light from a tungsten filament (2700° K.), but let infrared radiation pass freely.

Our brand new bulletin B-91, "VYCOR brand Industrial Glassware by Corning," completes the story with all the basic data we can put in print about all seven VYCOR brand glasses—with curves and illustrations. It just might stimulate an application idea or two for you. Would you like a copy?

On becoming attached—Nothing personal—just a first step, we hope, toward informing you about ways of attaching glass to metal.

We've found a lot of our customers have more than a passing interest in this subject. We do too, as you might imagine, what with some 50,000-odd formulas for glass hankering to be put to new uses.

Below, for example, is *one* of the "recommended methods of attaching glass to metal structures"—from a bulletin of that name!



This particular one is a soldered joint between glass and metal. The glass panel has a metallized edge to accommodate soldering to the metal frame.

The brochure (actually an editorial reprint from "Product Engineering") shows some 16 other types, including threaded joints, pressure-tight joints, spun-metal joints and electrical connections. We'd be delighted to send you a copy.

* * * *

Which brings us to our basic theme—glass itself. That's a world amazing even to those of us who spend most of our waking hours exploring its apparently endless boundaries.

What progress we've made to date, mostly working with folks who have materials problems to solve, is spelled out in a little volume we've offered before and offer again in light of the sustained demand for it. A copy of "Glass and You" will show how this centuries-old material fits 20th century technology. It's a good starting point for getting acquainted. May we send you a copy?

Corning means research in Glass

CORNING GLASS WORKS, 10-2 Crystal Street, Corning, N.Y.

Please send me the information checked below:

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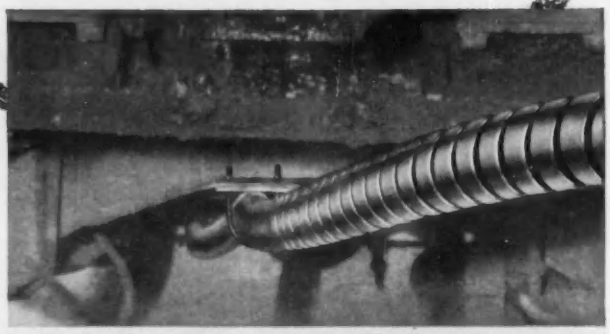
STOW flexible shafting ON THE JOB



pumping GAS on a tractor-trailer

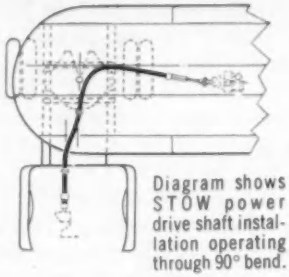


Diagram shows STOW power drive shaft installation operating through 90° bend.

STOW Flexible Shafts have effectively solved power take-off problems on both trucks and tractor-trailers. Large shafts, such as the 1¼" pictured above which transmits up to 10 H.P., have proven their ability on power take-off applications more efficiently and with more trouble-free service . . . **to operate pumps** for petroleum, milk and other liquids; **to operate conveyors** for grain, coal; **to operate compressors** on refrigeration trucks.

Why not put Stow to work on your power drive problems? Stow Engineers are always at your service.

For complete engineering data and illustrations on STOW Flexible Shafting—Write today for FREE Bulletin 525.

Write today for Bulletin 542 and complete data on Power Take-Off drives.

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Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

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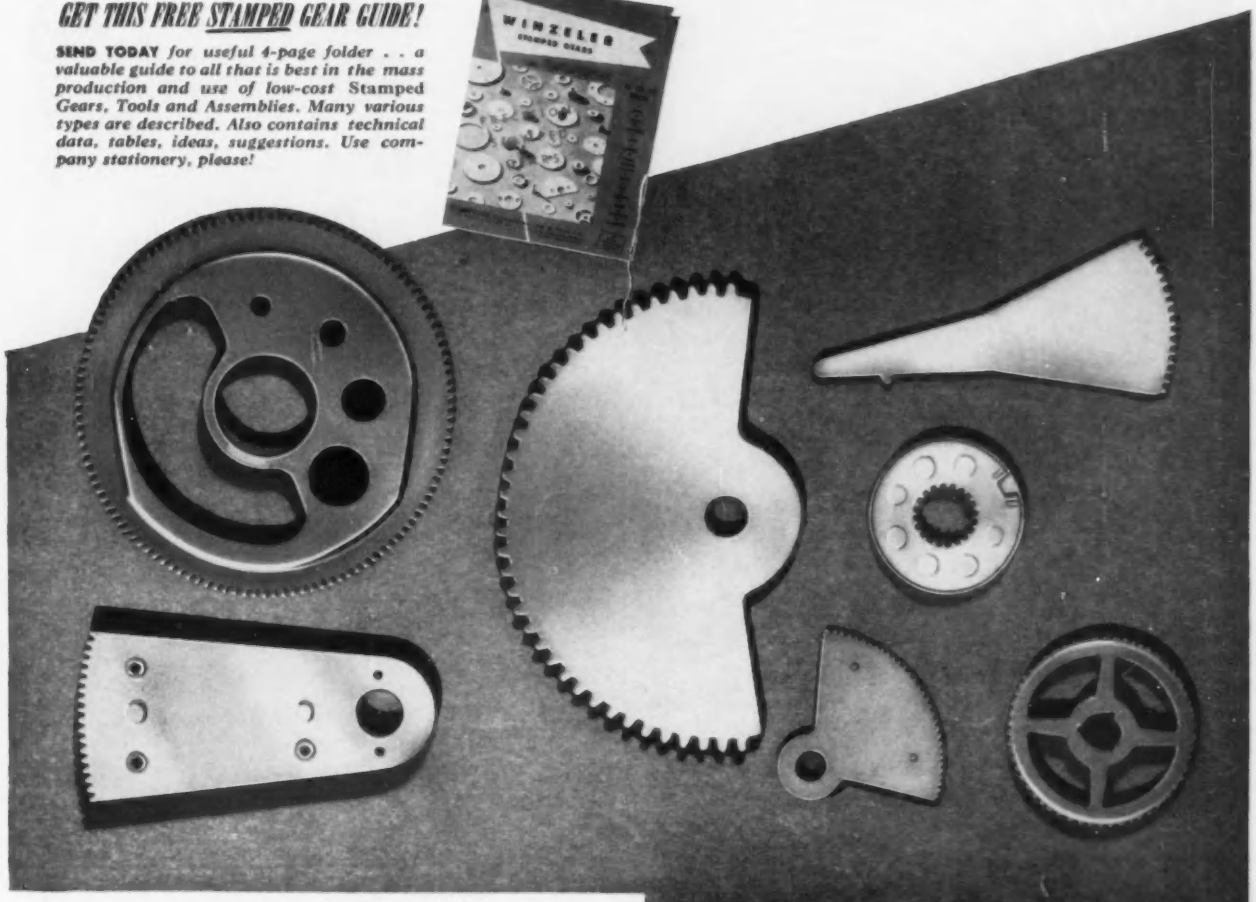

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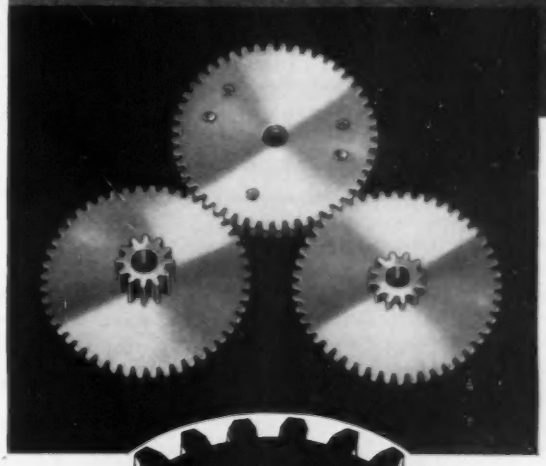

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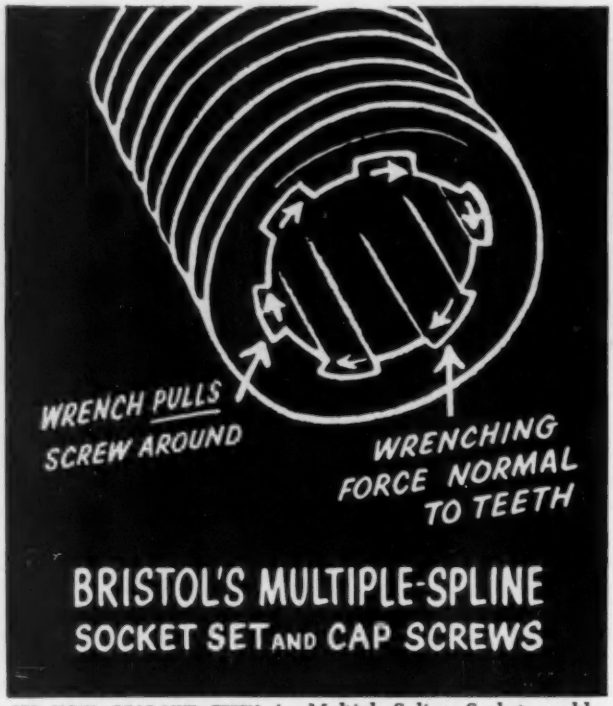


SEE HOW GEAR-LIKE TEETH in Multiple-Spline Socket enable wrench to *pull* screw around. No expanding pressure – *all* wrenching force is translated into rotary motion. Result: faster assembly, tighter wrenching for greater holding power. Bristol's Multiple-Spline Socket Screws can be wrenched thousands of times and never break or round out at high torque.

BETTER TWIST in socket screws — from elementary engineering principle

We're talking about the multiple-spline – you probably discussed it in your first year at engineering school.

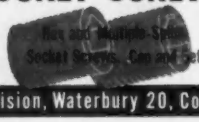
It was this age-old principle, recognized as one of the best means of transmitting rotary power (used on automobile drive shafts, rear axles and airplane propeller hubs, for example), that Bristol's design engineers thought of when they set out to build a *better* socket screw.

Here's what they discovered: internally splining the socket of an ordinary socket screw produced a screw that would never split or round out, yet have more "wrenchability" and hold tighter than any other screw.

That's the story behind the Bristol Multiple-Spline Socket Screw – now used wherever shock and severe vibration exist . . . wherever a *better* socket screw is needed.

If you're not already familiar with these extra-strong fasteners, we'll be glad to mail samples to you. Tell us the size and type you want (Bristol's Multiple-Spline Socket Screws are made in sizes from No. 0 wire to ½ inch – cap and set). A.4.12

BRISTOL'S SOCKET SCREWS



THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

Light metals design tips

When to consider impact extrusions

Light metal parts in almost limitless variety of simple and complex shapes, can be produced economically by the impact extrusion process. Practically any round, square, rectangular, oblong, cup-shaped or shell-shaped piece, with beaded or fluted walls, with bosses, recesses or projections can be made by the impact extrusion process. Here's when impact extrusions are a "must."

1. When the bottom is thicker than the side walls.
2. When the bottom must include bosses, projections or recesses.
3. When a bottom extending into a flange is required.
4. When side walls must have longitudinal ribs or flutes.
5. For short, open-end tubes not producible by direct extrusion or drawing.
6. Generally, when the length-diameter ratio exceeds 2 to 1.

Write for our new Impact Extrusion Bulletin, or for help on any light metals problem.

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LIGHT METALS FABRICATION DIVISION • EAST CHICAGO 27, IND.

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1. Unlimited life within borders of permissible loads.
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7. Large impact damping especially with multiple stacking.
8. Excellent space disposition.
9. Spring pressure, Spring length and Spring deflection can be easily determined for the same Spring size or can be changed by lengthening or shortening of the Spring columns or by multiple stacking. In special cases the character line can be made to divert from its usual form by diversified stacking.
10. Most Spring sizes available from stock.

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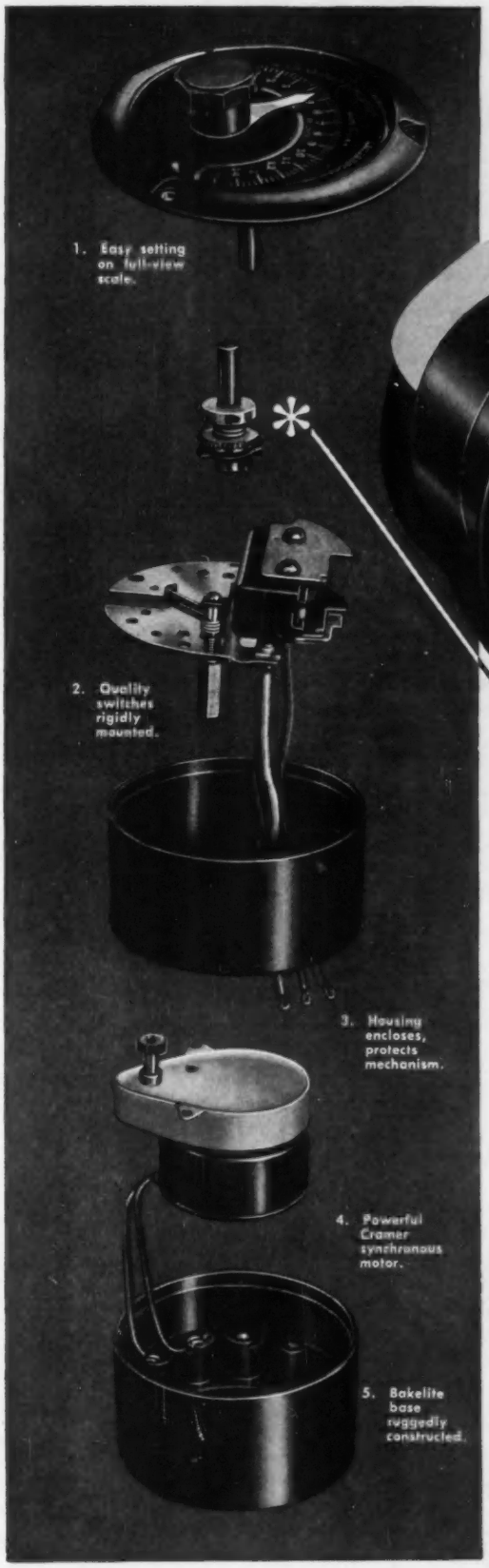
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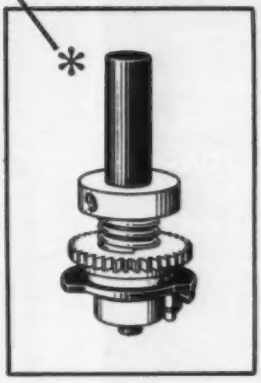
. . . manually set to control the opening of one circuit and closing of another for a selected time interval.



A "look inside" the Type 230 Interval Timer illustrates how design simplicity and precision workmanship contribute to trouble-free performance.

For example, the friction clutch assembly shown at left has few operating parts, yet is highly efficient. All friction forces are held internally within the clutch. No force is exerted either up or down to cause unnecessary load on the motor. The clutch essentially "floats" in the timer, thus minimizing wear, increasing reliability, and contributing to long motor and timer life.

Every component of every Cramer timer has been designed for simplicity, accuracy and operating dependability. For the complete story on interval timers, write for Bulletin PB-210.

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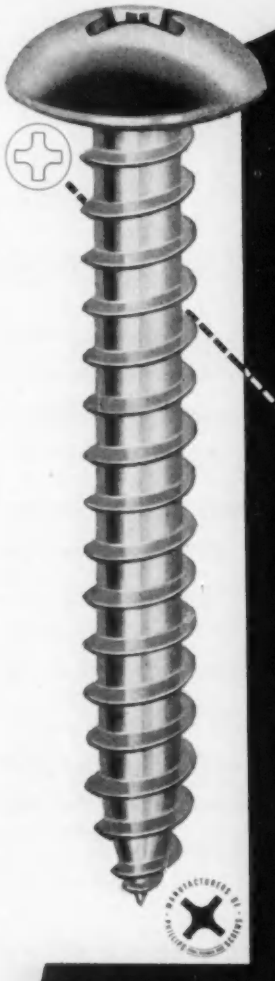
ELCO PHILLIPS CROSS-RECESSED SCREWS



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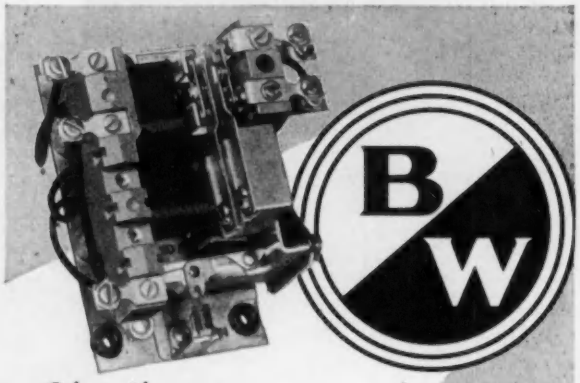

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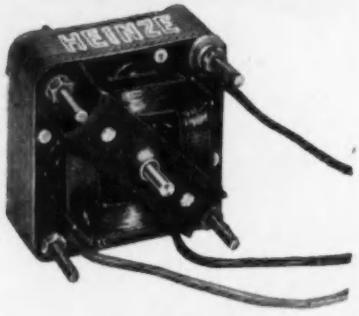

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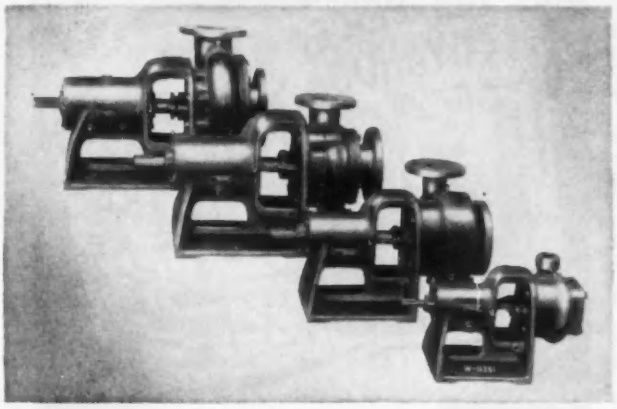
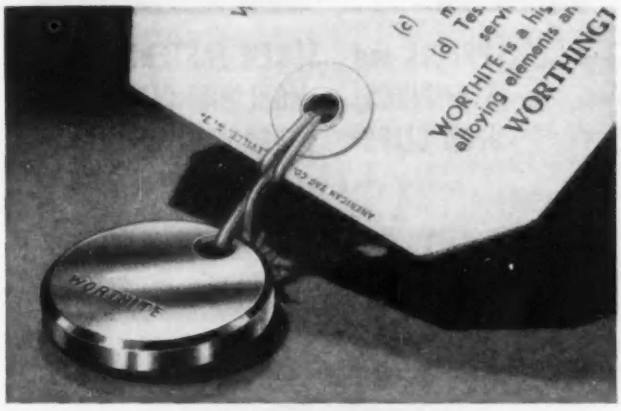
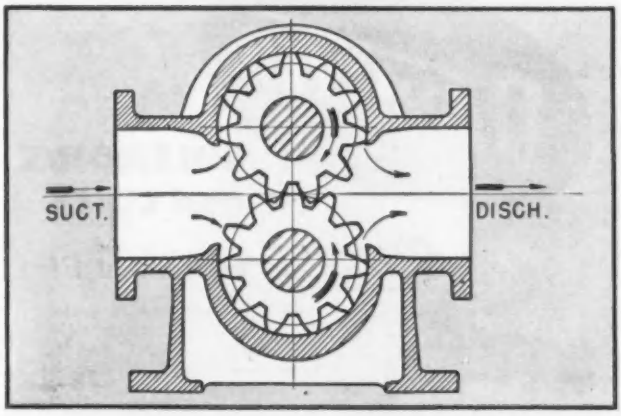
* Pump Quotient



Why are more and more end-suction pumps being specified? The answer's *simplification.* Industry is turning to end-suction pumps because they simplify piping (especially in process applications), need only one stuffing box, and make parts replacement easy. Get the full story on the Worthington end-suction pumps by writing to Section PC.4.8.



What is Worthite? Worthite is Worthington's "super-stainless", corrosion-resisting alloy steel containing more than 50% of the alloying elements: nickle, chromium, molybdenum, silicon, copper and manganese. The balance is mainly iron. Worthite was first introduced in 1936 and has gained wide acceptance as an excellent construction material for applications where corrosion is a problem. Worthington, of course, offers a complete line of Worthite pumps. Write for Bulletin W-350-B4.



Why are gear-type rotary pumps best for handling high-viscosity fluids? Lots of reasons. First, their large, unobstructed passages mean low entrance losses. Then, there aren't any valves or valve springs. Also, there's the flexibility in application offered by the wide speed range of gear-type rotaries. Write for Bulletin W-483-B2 for facts about the Worthington double-herringbone gear rotary pumps and vane pumps. PC.4.10

Write today for bulletins on end-suction pumps, Worthite and gear-type rotary pumps. Worthington Corporation, Merchandising Division, Section PC.4.10, Harrison, New Jersey.

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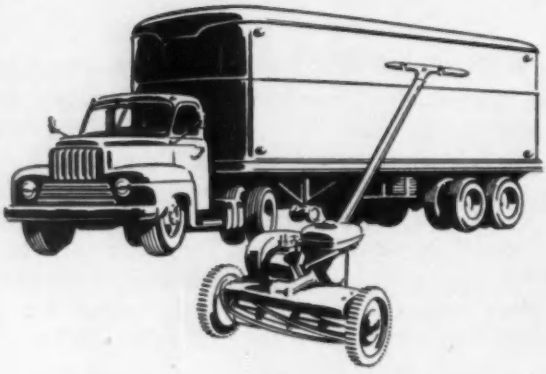

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On the other hand, if your carburetor requirements are highly specialized, Zenith's engineering experience will prove invaluable in solving questions of placement, efficiency and economy of operation. Just remember, whatever your carburetor problem, it will pay you to look to Zenith for the answer. *REG. U. S. PAT. OFF.

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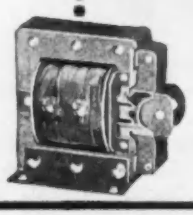

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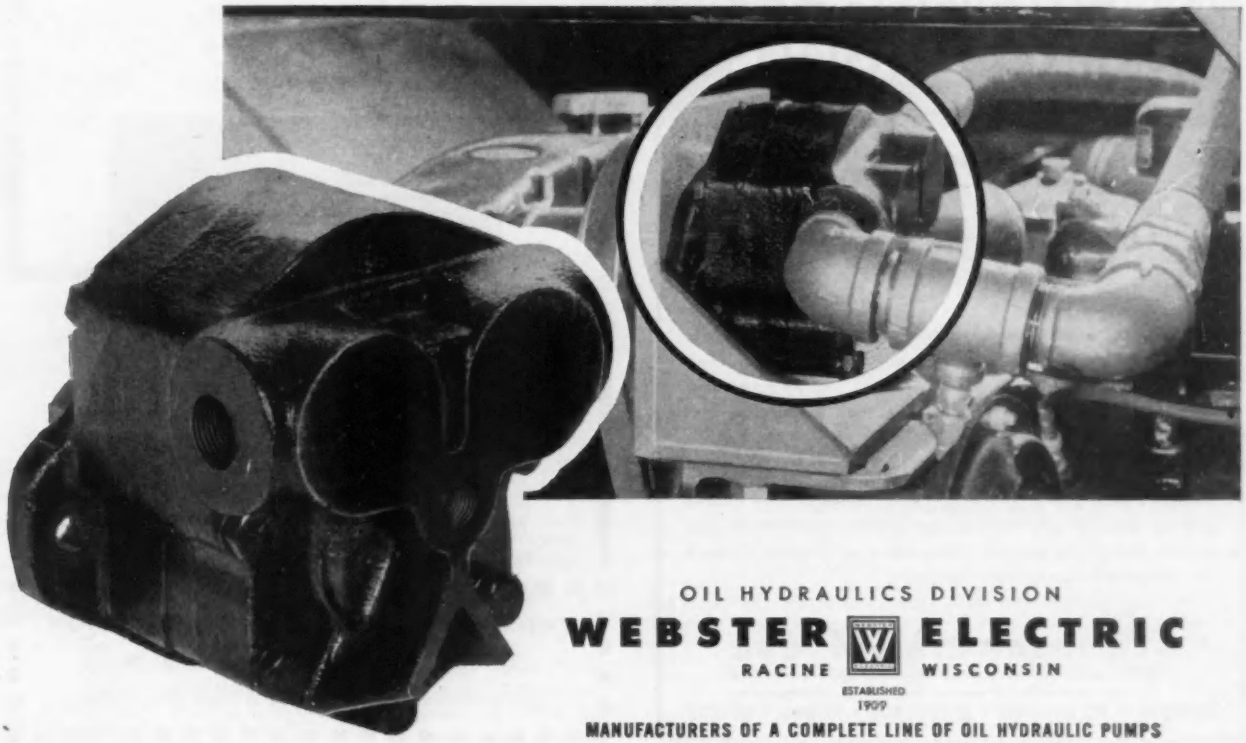
DRIVES.....Direct, gear, belt

Space-saving WEBSTER Hydraulic Pump fitted into tight quarters under Jeep hood



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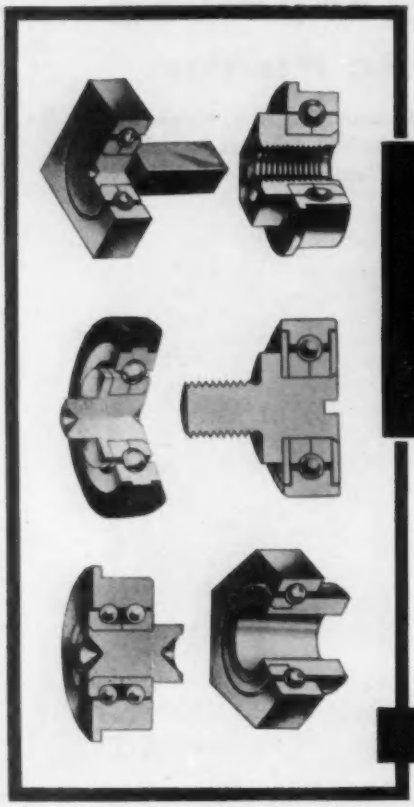

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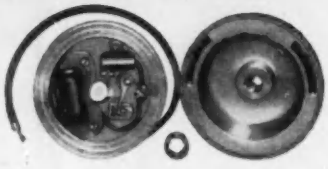
BIG NEWS FOR DESIGNERS OF SMALL ENGINES



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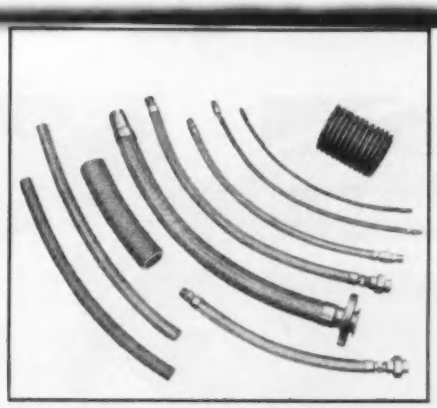

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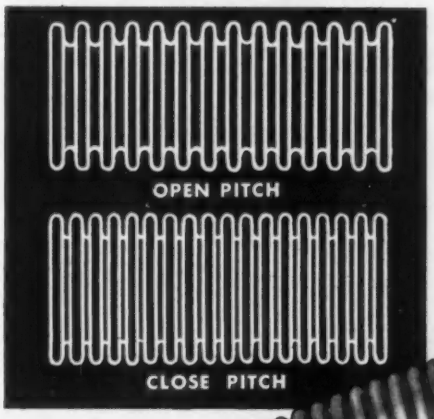

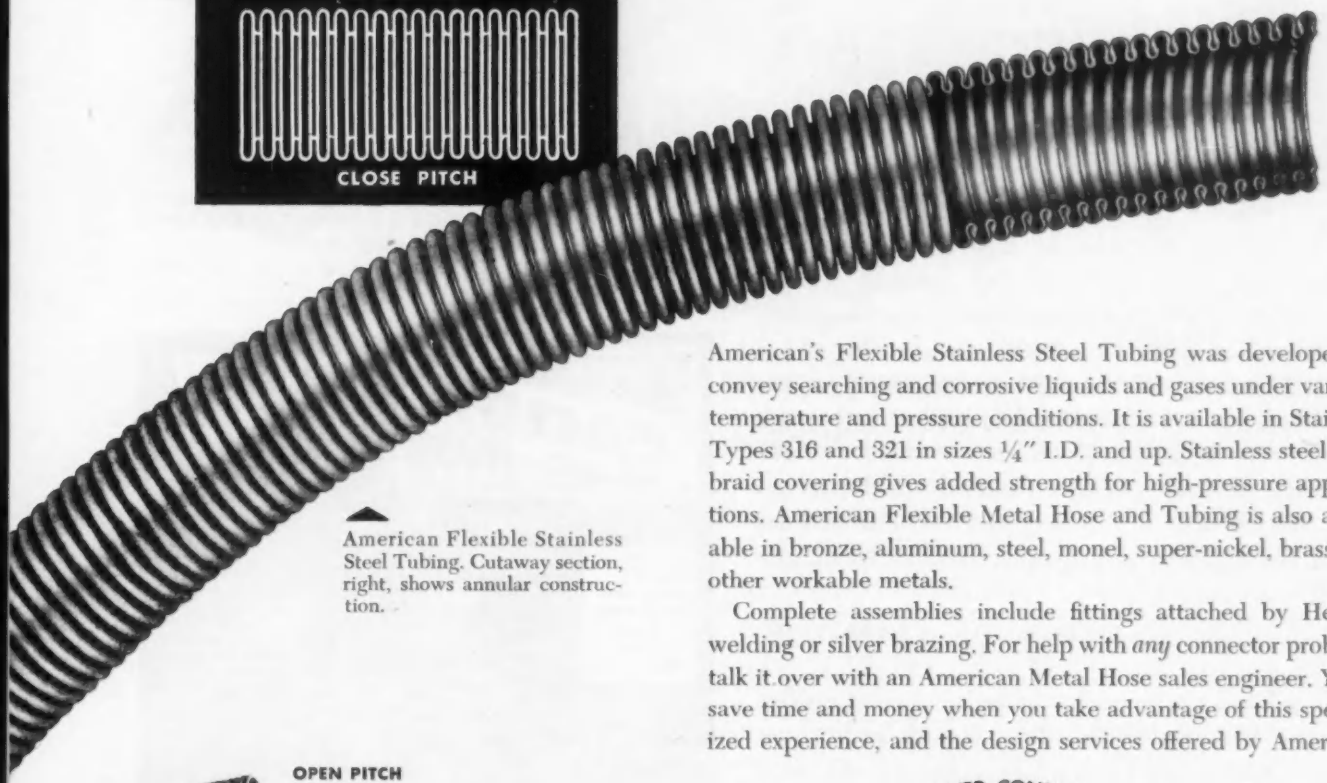

American Flexible Stainless Steel Tubing. Cutaway section, right, shows annular construction.

American's Flexible Stainless Steel Tubing was developed to convey searching and corrosive liquids and gases under varying temperature and pressure conditions. It is available in Stainless Types 316 and 321 in sizes ¼" I.D. and up. Stainless steel wire braid covering gives added strength for high-pressure applications. American Flexible Metal Hose and Tubing is also available in bronze, aluminum, steel, monel, super-nickel, brass and other workable metals.

Complete assemblies include fittings attached by Heliarc welding or silver brazing. For help with *any* connector problem, talk it over with an American Metal Hose sales engineer. You'll save time and money when you take advantage of this specialized experience, and the design services offered by American.

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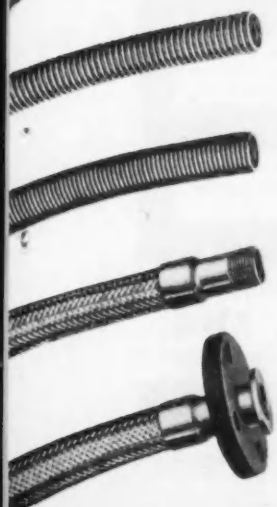

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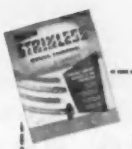

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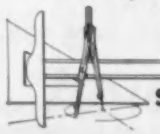

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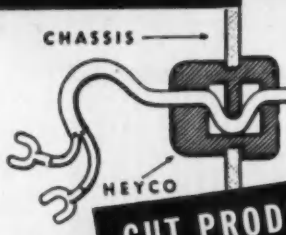

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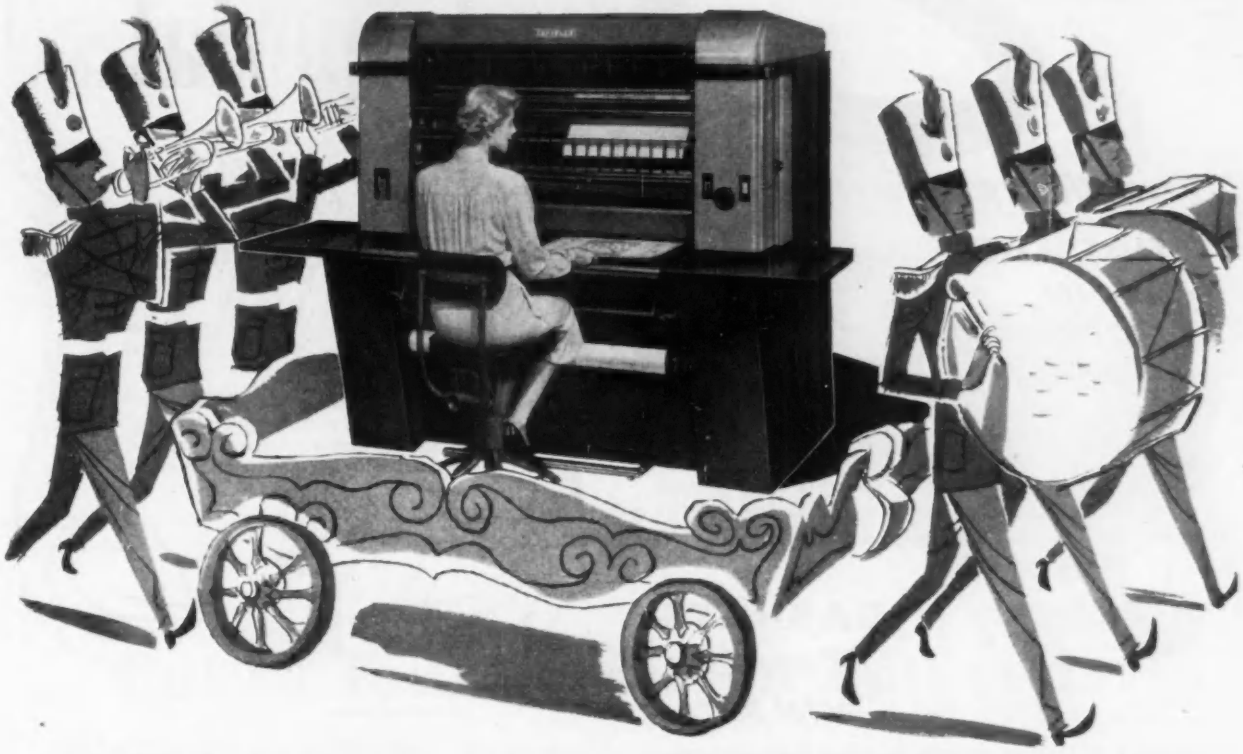

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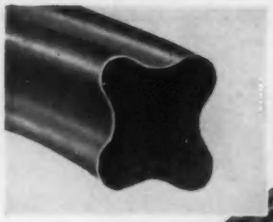

Free Sample

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Revolutionary new Hydraulic Seal

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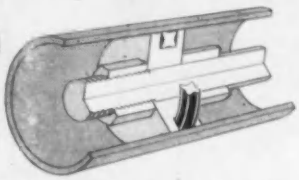
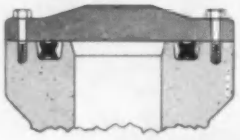


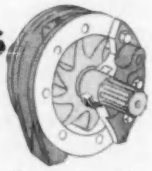
New design eliminates "spiral twist," common cause for packing failure. Users report much less drag and break-away in installations with QUAD RINGS. Leading edge acts as wiper ring to minimize abrasion and prolong service life. QUAD RINGS form a positive seal under a wide range of pressures—are particularly efficient at 0 to 5 psi.



2 GASKETS *for matching metal parts*

QUAD RING design prevents excessive distortion under pressure. The four lips prevent "by pass" in devices using frequent pressure cycles. Reduced "working action" in the groove permits rougher groove finish. Made in a complete range of sizes corresponding with O-rings. Completely interchangeable with O-rings, eliminating any conversion costs.

3 ROTARY SEALS *on revolving shafts*



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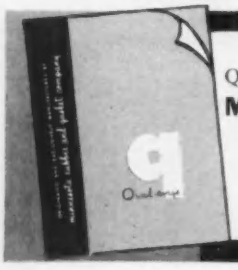
QUAD RINGS are the result of intensive research by Minnesota Rubber. Field tested for 2 years. QUAD RINGS are injection molded to the closest possible tolerances. Free samples are available with technical information and installation data. Write today.



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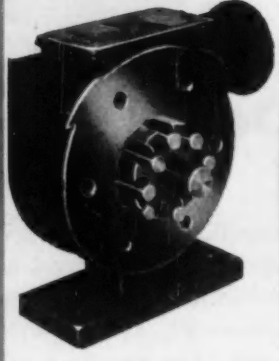

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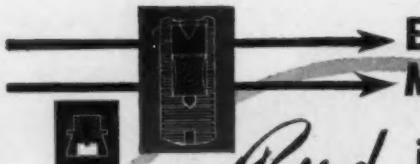

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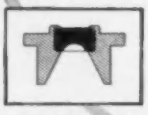
use *Bird* jewel assemblies



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all-american team

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- They train 82,000 undergraduates, specialists and technicians and graduate 6,500 doctors annually.
- It costs from $10,000 to $12,000 to train a doctor today.
- Tuition fees, raised 84% over 1940, cover about 20% of cost.
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- The medical schools need $10,000,000 annually in additional income to maintain present standards and train the necessary number of doctors required for America's growing population.
- *ALL* 79 medical schools can be aided by a *single* gift to the National Fund for Medical Education.
- Contributions are distributed through annual grants according to a schedule approved by the medical schools.
- The National Fund is a voluntary, non-profit organization approved and supported by the American Medical Association and the Association of American Medical Colleges.

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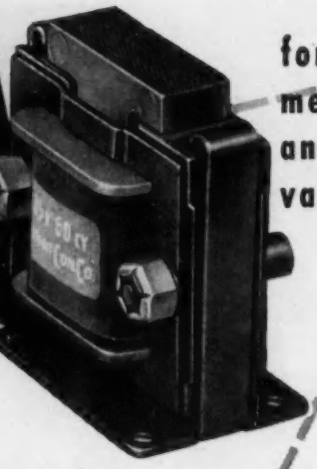

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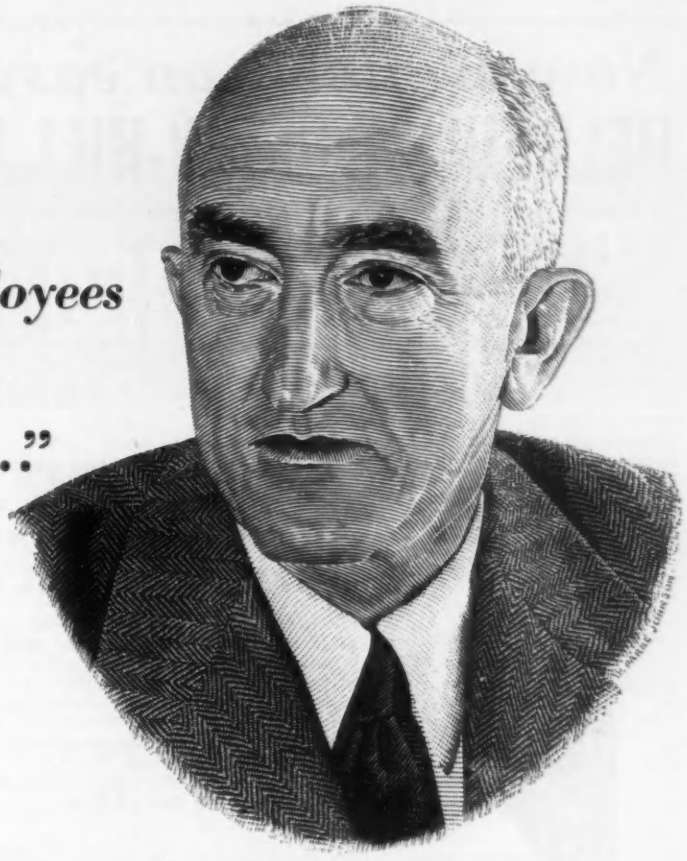

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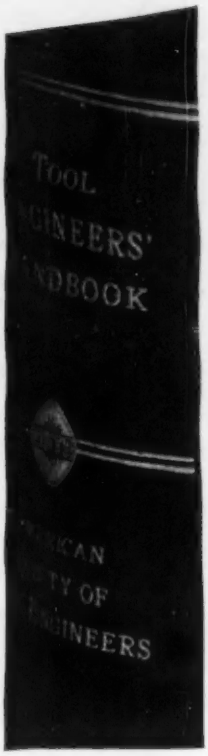

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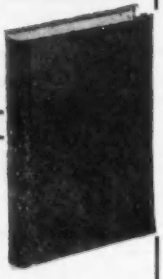

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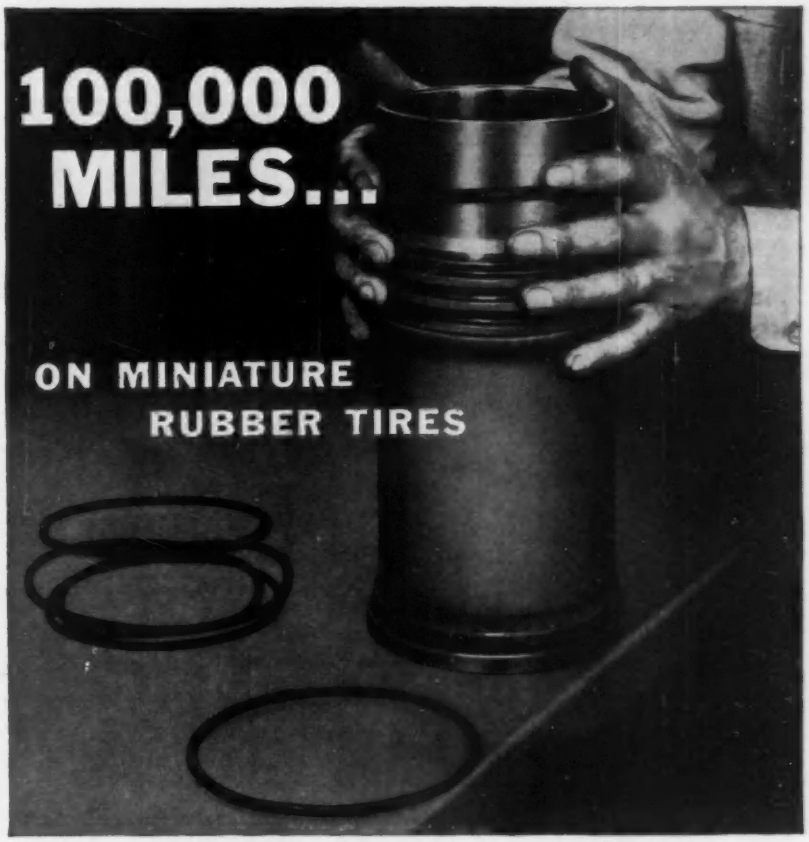

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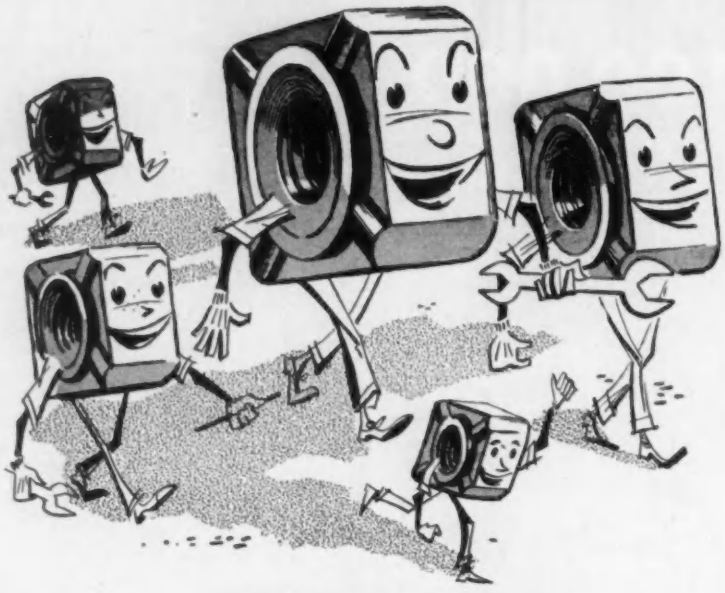

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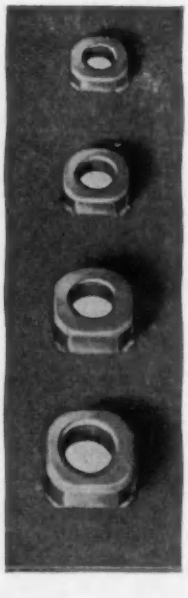

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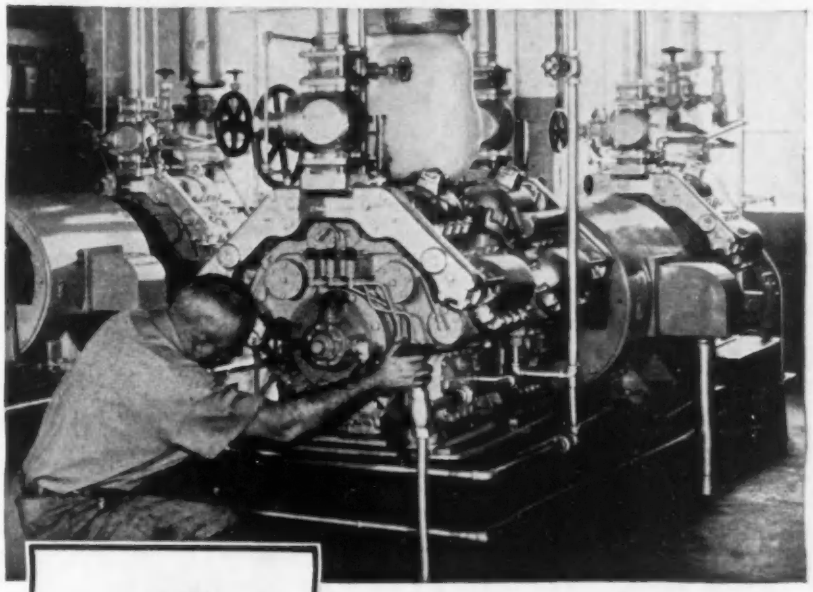

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R356	357	TL358	BL358	R358	359	R360	L360	361	L362	TR362	363	L364	TR364
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L380	TR380	BR380	T382	BL382	L384	TR384	BR384	386	387	L390	R391	R393	L394
R395	L396	R397	400	C3	C4								

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187	188	189	190	191	192	193	194	195					

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74—Modular Bobbinless Resistors
75—Adjustable Capacitors
76—High Gain Magnetic Amplifier
77—Metal Film Resistor
78—Cast Ceramic Power Resistors
79—Subminiature Preamplifier
80—Blower for Electronic Equipment
81—Synchros of 1.437 in. Max Dia
82—Blower Will Move 525 Cfm Free Air
83—Miniature Silicon Junction Diodes
84—Cylinders With Integral Valves
85—Operates On Oil or Water
86—Hydraulic Power Unit
87—Solenoid Air Valve
88—Coaxial Metering Flow Valve
89—Semi-Direct Lift Solenoid Valve
90—Spring Loaded Relief Valve
91—Capillary Tube Fitting
92—Solenoid Valve for 200 Psi
93—Pop-Off Relief Valve
94—Water Pressure Release Adapter
95—Hydraulic Hose and Couplings
96—Compressed Air Filter
97—Sump Drain for Compressed Air
98—Fluid System Strainers
99—Impact, Abrasion Resistant Steel
100—Resists Rusting, Corrosion
101—Lower-Priced Acrylic Sheet
102—Silicone Rubber-Coated Fabric
103—Bearing Material
104—Plastic with High Strength
105—Miniature Molded Rubber Parts
106—Oscilloscope Camera
107—Template Rolls to 62 In.
108—Contrast and Sharpness Increased
109—Isometric Protractor
110—Blueprint Reading Stand
111—D-c Power Supply
112—Internal Micrometer
113—Power Supply
114—Synchronous Motor Dial Drive
115—Portable Insulation Test Set
116—Accelerometer

NEW BULLETINS . . . listed below are described on pages 286 to 302. Circle key number for your copy.

117—Stainless and High Alloy Tubing
118—Forgings
119—Porous Stainless Steel
120—Testing Shakers
121—Flexible Couplings
122—Clad Steel Plates
123—Air Motors, Compressors, Pumps
124—Glass Products
125—Flame Failure Guard
126—Motors of 1/200 to 1/40 Hp
127—Nickel Cast Irons
128—Temperature Equivalents
129—Porous Fluorocarbon Filter
130—Screw Inserts
131—Instrument Parts and Components
132—Copper Alloy Strip
133—Filters, Lubricators
134—Valves
135—Zinc Die Castings
136—Fastener with Washer
137—Thermostats
138—Synchronous Motors
139—Wire and Cable
140—Steam Jet Vacuum Pumps
141—Steam and Air Jet Syphons
142—Sub-Miniature Pilot Lights
143—Metal Bellows and Hose
144—Film-Type Heating Elements
145—Vacuum Tube Voltmeters
146—Torque Converter Couplings
147—Magnetic Disc Brakes
148—Plastic-Covered Wood
149—High Temperature Rectifiers
150—Voltage Regulator

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. . . PRODUCTS ADVERTISED

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18-19	20-21	22-23	24-25	26	-27	28-30	30	31	32	32a-b	33	34	35
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283	L284	285	287	L288	289	BL290	R291	L292	292a-b	R293	L294	295	TL926
BL296	297	L298	299	L300	R301	L302	303	L304	305	L306	R307	L308	R309
L310	311	L312	R313	L314	315	L316	R317	L318	R319	L320	R321	L322	323
L324	325	326	327	L328	TR328	BR328	329	330	331	L332	R332	L334	TR334
BR334	335	L336	TR336	BR336	337	338	339	340	341	342	343	T344	B344
345	346	347	348	349	350	351	L352	TR352	BR352	353	L354	R354 355	L356
R356	357	TL358	BL358	R358	359	R360	L360	361	L362	TR362	363	L364	TR364
BR364	365	L366	367	L368	TR368	CR368	BR368	369	L370	TR370	BR370	371	L372
TR372	BR372	373	T374	BL374	BB374	375	L376	TR376	BR376	377	378	TR278	379
L380	TR380	BR380	T382	BL382	L384	TR384	BR384	386	387	L390	R391	R393	L394
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. . . SPECIFIC DATA . . .

Card expires April 1

151—Permanent Magnetic Pulleys
152—Weight and Tension Instruments
153—Standard Cast Shapes
154—Infinite Control Switch
155—Insulation Testing
156—PVC Valve and Fittings
157—Motor-Alternator
158—Squirrel-cage Motor Starters
159—Fasteners
160—Time Delay Relays
161—Aluminum Mill Forms
162—Molybdenum Disulfide Lubricant
163—Unidirectional Electric Motors
164—Stainless Steel Tubing
165—Automatic Switches, Timers
166—Pneumatic Transmitter
167—Hose Couplings
168—A-c Motors
169—Level Indicators
170—Armored Motors
171—Peelable Plastic Packaging
172—Vacuum Tube Electrometers
173—Tetrafluorethylene Products
174—Hydraulic Equipment
175—Pneumatic Production Equipment
176—Mechanical Seals
177—Oil Burner Controls
178—High Resistance Measurement
179—Motor Speed Control
180—Steel Tubing
181—Hydraulic Fluid
182—Water Heating, Cooling Equipment
183—Oil-Tight Push Buttons
184—Subminiature Switches
185—Conveyor Belts
186—Terminal Blocks
187—Flange-Mounted Motor
188—Electrolytic Nickel Powder
189—Valves
190—Relay Steels
191—Hydraulic Pumps and Valves
192—Voltage Measurement
193—Permanent Magnet D-c Motors
194—Line Voltage Regulator
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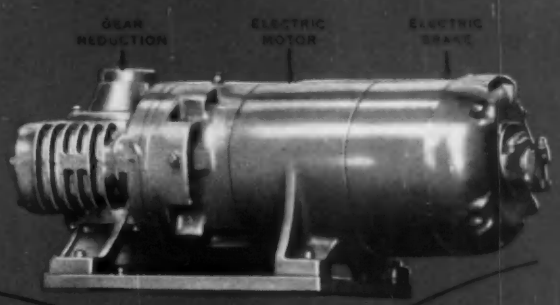

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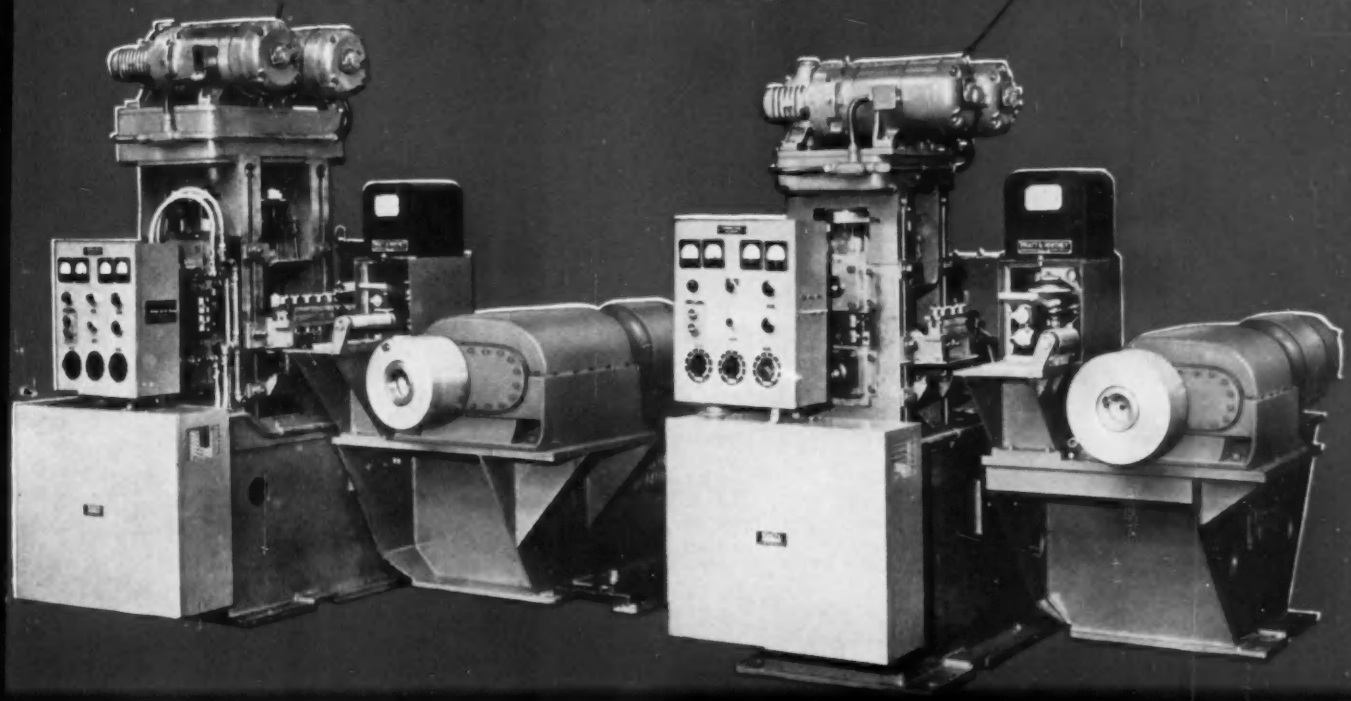

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